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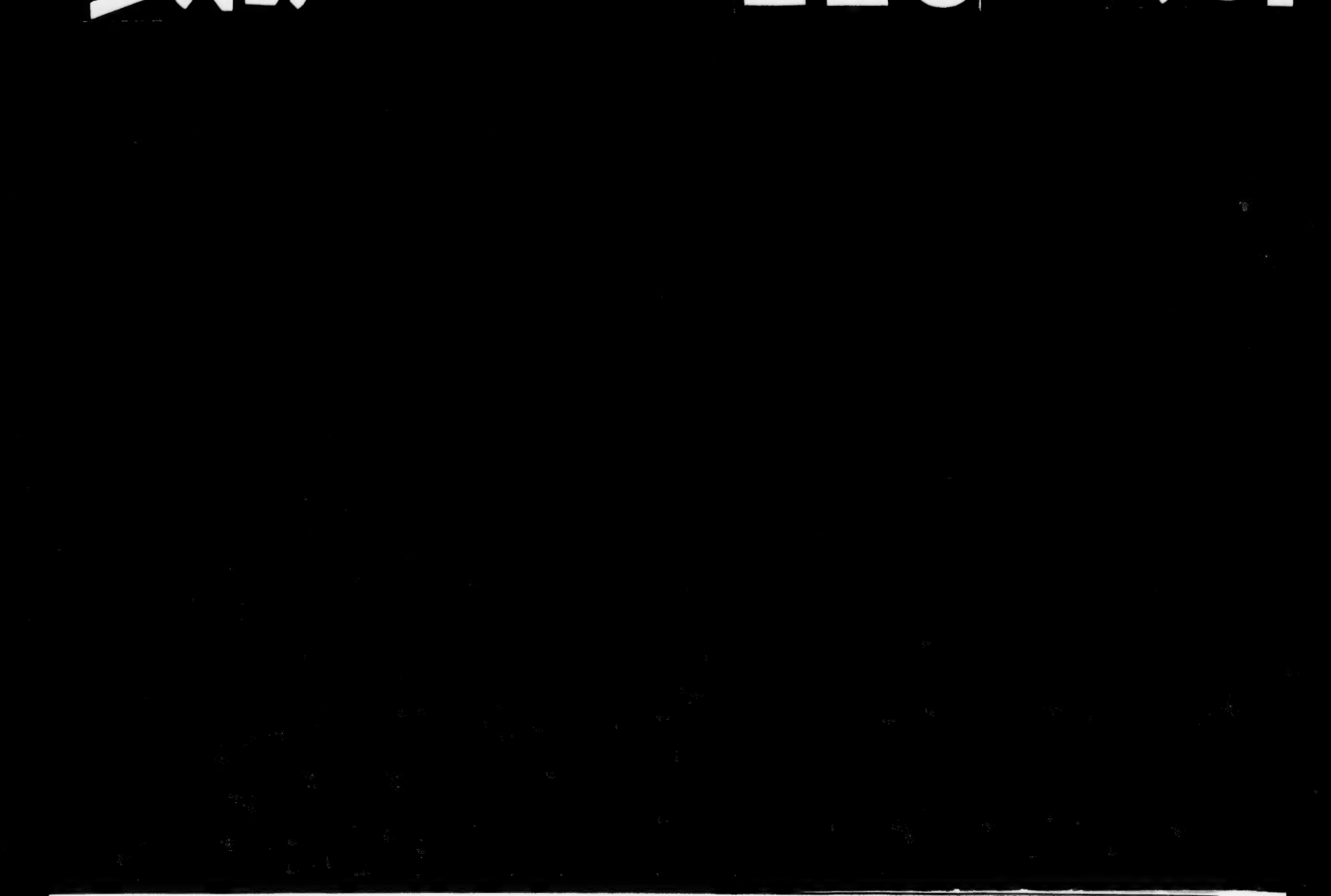

# THE ACTINOCEROIDS OF EAST-CENTRAL NORTH AMERICA

AUG. F. FOERSTE AND CURT TEICHERT[1]

*Received November 5, 1930; published December 23, 1930*

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[1] Graduate, Univ. Königsberg, 1927; assistant geologist, Univ. Freiburg, 1927–1929; fellow, Rockefeller Foundation, 1930.

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## INTRODUCTION

The actinoceroid cephalopods are of special interest because they appear to have originated in the American Arctic seas and to have had a circumpolar distribution. They abound in the Ordovician of northern Greenland and are widely distributed thence southward over the American Arctic Archipelago and the northern half of the North American continent. Along the Atlantic coast they reach Newfoundland, Anticosti, and the Bay of Chaleur. Farther inland, they reach Tennessee, Missouri, and Oklahoma.

Farther northward they extend to Iowa, Minnesota, and Manitoba. In the Rocky mountain area they extend to Montana and British Columbia. From the area southwest of Hudson Bay they extend westward to Great Slave Lake and one specimen was found on the American side of Bering Strait, in Alaska. On the eastern side of the Asiatic continent they are abundant in southern Manchuria and in northern China. Several species have been found on Bear island, halfway between the northern end of Norway and Spitzbergen. A few specimens have been found in western Europe, in Esthonia, southern Scandinavia, and England. Compared with their abundance on the North American continent and in eastern Asia, they evidently are only scantily represented in western Europe, while in Russia and Siberia they are, so far, unknown.

In addition to their approximately circumpolar distribution, the actinoceroids are of interest also on account of their wide variation in form and structure, especially in the structure of their siphuncles, leading to many new generic terms. There is still much to learn about the structure of the walls of these siphuncles, especially about their septal necks, and the calcareous deposits lining or filling these siphuncles need much further study. Moreover, the apical ends of the conchs of some of their genera, or at least the earliest parts of these conchs still preserved, are very inadequately known. Some of these so-called apical ends enlarge with remarkable rapidity to unusual proportions, and while it is evident that they can not be the initial parts of the conchs, nothing earlier than these blunt apicad ends has so far been found.

The earliest representatives of the actinoceroids discovered so far are from the Chazyan. However, these Chazyan forms vary sufficiently in structure to suggest that the origin of this group must have occurrred in pre-Chazyan times. Actinoceroids are especially abundant in the middle Ordovician, they occur in fair numbers in the Silurian and Devonian, and are seen last in the Carboniferous.

In this paper the term actinoceroid is used in its old sense, for those cephalopods in which the segments of the siphuncle are more or less nummuloidal, and in which the interior of these siphuncles

is more or less lined or filled with calcareous deposits, these deposits usually originating as annular films starting on the inner surface of the septal necks, and increasing in thickness and width by continued deposition. For these conchs the term *annulosiphonate* would be more accurate, but the older expression *actinoceroid* is more familiar.

As a result of our studies, it seems advisable not only to adopt some of the new families recently proposed for the Annulosiphonata, but to add one of our own, attempting to give a clearer definition as to their limits. The basis of this classification is discussed on the following pages.

## ORTHOCHOANITES AND CYRTOCHOANITES

Among those nautiloid cephalopods whose siphuncles include both septal necks and connecting rings, the two chief suborders are the Orthochoanites and the Cyrtochoanites.[2] In the former the segments of the siphuncle usually do not enlarge sufficiently to become globular, and never enough to be called nummuloidal, the lower margin of their septal necks does not curve strongly outward, and the interior of the siphuncle either is free from calcareous deposits, or is so little occupied by these deposits that no endosiphuncle results from their growth. In the Cyrtochoanites, on the contrary, the segments of the siphuncle often are conspicuously broader than globular, so as to be called nummuloidal; the lower margin of the septal necks curves strongly outward, and calcareous deposits are abundant, often obstructing all but the central part of the siphuncle, leaving at this center a vertical irregular tube-like space, called the endosiphuncle.

In the case of those species having siphuncles whose segments are almost globular in form, but free from calcareous deposits, it sometimes is difficult to determine in which suborder they should be placed. Apparently these are initial forms of the Cyrtochoanites, the habit of filling the interior of their siphuncles with calcareous deposits being adopted at later stages of growth. Even in typical actinoceroids the upper parts of the siphuncle often are

[2] Hyatt, Alpheus, in Zittel-Eastman, Text-book of Paleontology, 1913, pp. 595, 598, 608, 609.

entirely free from calcareous deposits, all intermediate stages of deposition being exhibited on descending to earlier segments, while the more apicad parts of the siphuncle may be almost completely filled.

### ANNULOSIPHONATA AND ACTINOSIPHONATA

Hyatt divided his suborder *Cyrtochoanites* into two main divisions: the Annulosiphonata and the Actinosiphonata.

In the Annulosiphonata, calcareous deposits encrust the interior of the septal necks in the form of transverse rings which, in vertical sections, present lunate outlines. Evidently these rings continue to grow inward until all but a narrow central part of the siphuncle, irregularly tubular, is filled. This central part, later filled with matrix, is called the endosiphuncle.

In the Actinosiphonata, on the contrary, the calcareous deposits are not continuous laterally, but take the form of vertical lamellae which converge from the walls of the siphuncle toward its center, however without actually reaching the latter. These lamellae are often not continuous vertically, but are interrupted at rhythmic intervals, either at mid-height within the segments of the siphuncle, or nearer the septal necks.

The known actinosiphonate forms have been reviewed recently by Foerste.[3] However, it is not yet known definitely to what extent the presence of actinosiphonate structure is of taxonomic value, as contrasted with annulosiphonate structure. Certain groups, such as the Jovellanidae, the gomphoceroids, and the phragmoceroids are characterized by actinosiphonate structure, but it is not known to what extent this structure is to be expected in all species belonging to the same genus, or in all individuals within the same species.

It must be admitted that some of the genera placed by Hyatt among the Actinosiphonata never have been known to contain any actinosiphonate structure. Moreover, two of these genera, namely *Eremoceras* and *Cyclostomiceras*, must even be removed from the Orthochoanites and placed among the Holochoanites.

[3] Foerste, Aug. F., Actinosiphonate, trochoceroid, and other cephalopods; Jour. Sci. Lab., Denison Univ., vol. 21, 1926, pp. 285–383, pls. 32–53.

Hyatt divided his Annulosiphonata into three families: the Loxoceratidae, Uranoceratidae, and Actinoceratidae.

In the Loxoceratidae, as defined by him, the calcareous deposits, when present, are irregular in occurrence and rarely fill the interior of the siphuncle sufficiently to leave anything resembling a central tube-like cavity or endosiphuncle.

In the Uranoceratidae the segments of the siphuncle are more distinctly nummuloidal, but do not contain conspicuous calcareous deposits, and frequently are entirely empty.

In the Actinoceratidae, the calcareous deposits usually are conspicuous and the endosiphuncle almost invariably is present.

The paper here presented is devoted chiefly to those Annulosiphonata which Hyatt included in his Actinoceratidae. However, this term is used here in a more restricted sense, and Hyatt's group, more broadly conceived, is divided into several smaller families, most of which were already indicated by Clarke and Troedsson, only one additional term being suggested by the present writers.

## ACTINOCERATIDAE

A relatively large number of genera possessing very different types of structure were included until recently under the term Actinoceratidae. This was due partly to the fact that so little was known of the exact structure of their siphuncles, especially of their septal necks, even in the case of some very common genera. However, as it became more evident that differences in the structure of these necks was of great importance in the systematic classification of cephalopods the study of these necks became more intensive, and the results more detailed. Ordinary photographs of natural size no longer were regarded as sufficient in the delineation of such structures, and in 1926 Gustaf Troedsson, in his studies of the Ordovician cephalopods of Northern Greenland, introduced numerous photographs of septal necks of the siphuncles of various genera, magnified from 4 to 6 diameters. Moreover, ordinary vertical sections through the siphuncle, viewed by reflected light, have not always proved satisfactory, and the junior author of this paper recently resorted to vertical translucent sec-

tions, viewed by transmitted light, to unravel the structure of the septal necks of such genera as *Elrodoceras* and *Westonoceras*, and of the species *Armenoceras richardsoni*, which appeared, at first, to lack a definite brim or recurved part at the lower end of the septal necks. As a result of these studies, however, it is now evident that a distinct recurvature of the septa takes place both in *Elrodoceras* and *Westonoceras*, and that in *Armenoceras richardsoni* the brim is present, but in such close contact with the overlying septum that its presence can be discovered only by transmitted light.

The result of these studies has been the introduction of numerous new generic names, especially among the Actinoceratidae. However, as the number of these names increased the conviction grew that the Actinoceratidae, when thus broadly conceived, included several types of structure sufficiently distinct to warrant the division of this group into several subfamilies or families.

Already in 1897, John M. Clarke[4] had proposed the term Gonioceratidae for the single genus *Gonioceras*. The species *Gonioceras lambei* Whiteaves, later used by Foerste as the genotype of *Lambeoceras*, he placed under *Tripteroceras*, and followed Hyatt in placing *Tripteroceras* under the Eudoceratidae, a very questionable procedure in view of the fact that the siphuncle of the Devonian genus *Eudoceras* is unknown. Troedsson, in his studies of the Ordovician cephalopods of Northern Greenland, in 1926, found the structure of the septal necks of *Lambeoceras* so different from that of *Gonioceras* that he followed Clarke in placing it among the Eudoceratidae. In the present publication we place *Lambeoceras* at least among the Cyrtochoanites, rather than among the Orthochoanites, adding it to the Gonioceratidae, though recognizing the validity of Troedsson's observations that the structure of the septal necks of *Lambeoceras* is very different from that of typical *Gonioceras*, the recurvature of the lower margin of its septal necks being much less, and its implantation upon the upper margin of the underlying connecting ring of an altogether different type.

[4] Clarke, John M., The Lower Silurian Cephalopoda of Minnesota, Geol. Surv. Minnesota, vol. 3, pt. 2, 1897, pp. 791, 794.

The term Armenoceratidae was first proposed by Troedsson[5] in 1926, to include the genera *Armenoceras, Huronia, Huroniella, Megadiscosorus, Discosorus,* and *Stokesoceras.* Among the typical Actinoceratidae he retains *Actinoceras, Kochoceras, Calhounoceras, Leurorthoceras, Ormoceras,* and *Nybyoceras.* In proposing the term Armenoceratidae he states that the septal necks of *Armenoceras* belong to quite another type from that shown by *Actinoceras,* but occur also in the other genera included by him under the Armenoceratidae. Unfortunately he does not state in what this difference consists but we presume that it consists in the presence of very short septal necks with abruptly recurved brims. To this family Armenoceratidae we here add the genus *Nybyoceras* which Troedsson defined as a subgenus of *Actinoceras.* However, we remove the genera *Huronia* and *Huroniella,* proposing for them the new family name Huroniidae, not because the structure of their septal necks is different from that of the Armenoceratidae, but because the upper parts of the segments of the siphuncle tend to enlarge in an annular manner, leaving the lower parts of the segments distinctly narrower, often with more or less distinctly concave vertical outlines, and always adnate to the upper surface of the underlying septa, so that the area of adnation between the septa and the lower part of the connecting rings is unusually long.

The term Sactoceratidae was used by Troedsson, in 1926, in place of Hyatt's term Loxoceratidae, chiefly because nothing is known of the structure of the siphuncle of *Loxoceras distans* M'Coy, if the latter is regarded as the genotype. But the conditions are not improved if the first species cited by M'Coy under *Loxoceras,* namely *Orthoceras* (*Loxoceras*) *breynii* (Martin), be used instead, because the latter belongs to the *Actinosiphonata,* while *Sactoceras richteri,* the genotype of *Sactoceras,* evidently belongs to the Annulosiphonata. Under his term Sactoceratidae, not defined by him, Troedsson includes *Sactoceras,* and *Eskimoceras.* However, the two species described by him under *Sacto-*

[5] Troedsson, Gustaf, On the Middle and Upper Ordovician faunas of Northern Grœnland; pt. I, Cephalopods. Jubilaeumsekspeditionen Nord om Grønland, 1920–23; no. 1, 1926, pp. 60, 106, 79, 43, 50.

*ceras*, namely *Sactoceras striatum* and *Sactoceras* (?) *lineatum*, have been used by Foerste in erecting his genus *Troedssonoceras*, which, therefore, also belongs to the Sactoceratidae.

The genus *Narthecoceras*[6] is anomalous in the structure of its siphuncle. By Hyatt it was placed among the Endoceratidae, and in this he is followed by Troedsson. However, it differs from all other known Endoceratidae in possessing segments of the siphuncle which present convex vertical outlines along the greater part of their length, concave outlines being restricted to their upper parts, the convex parts of their outlines being much longer than their concave parts. In typical Endoceratidae, on the contrary, the septal necks are concave for the greater part of their length and become convex only immediately above the point where they invaginate into the top of the next underlying neck. However, in *Narthecoceras* it has been found impossible, from the specimens at hand, to determine definitely whether the septal necks are continuous for the length of an entire camera, as in the Holochoanites, or whether these necks terminate along the lower margin of the short concave part of the segments of the siphuncle, the much longer convex part of their length corresponding to the connecting rings of the Orthochoanites and Cyrtochoanites.

*Narthecoceras* appears to be excluded from the Cyrtochoanites by the absence of strong outward curvature of the lower part of its septal necks. Moreover, the calcareous deposits within the interior of the siphuncle do not occur in annular form attached to the inner surface of the septal necks, as in the Annulosiphonata; nor in the form of vertical lamellae converging from the walls of the siphuncle toward its center, as in the Actinosiphonata.

From the Orthochoanites it appears to be excluded by the great abundance of the calcareous deposits within its siphuncle. These deposits appear to be arranged in lamellar layers attached to the interior of the walls of the siphuncle, gradually growing inward and extending farther upward, finally leaving only a narrow tubular central passage which, toward the upper part of the siphuncle enlarges into a very much elongated funnel-shaped cavity, later

[6] Foerste, Aug. F., The cephalopods of the Red River formation of southern Manitoba, Jour. Sci. Lab., Denison Univ., vol. 24, 1929, p. 187, pls. 24, 25.

filled by matrix. In some specimens, the central narrow tube is crossed at more or less rhythmic intervals by transverse partitions. This struction is entirely unknown among the Orthochoanites, but is comparable with the endocones, the endosiphuncles, and the dissepiments crossing the interior of the endosiphuncles of Endoceratidae and of other forms belonging to the Holochoanites.

This leaves the genus *Narthecoceras* without a certain abiding place, at least until specimens are found in which the septa are preserved and in which the structure and limits of the septal necks can be determined. In the meantime, its relationship to the Endoceratidae appears at least likely, though not definitely established.

The genus *Calhounoceras*,[7] proposed by Troedsson in 1926, presents a similar problem. No trace of the septa remains and the septal necks can not be differentiated from the connecting rings in the specimens found so far. The constrictions between the segments of the siphuncle are much stronger than in *Narthecoceras*. The calcareous deposits within the siphuncle are arranged in vertical lamellae converging toward the center of the siphuncle. The central tube-like cavity left by these deposits is crossed by relatively numerous transverse fine dark lines, suggesting dissepiments similar to those of *Narthecoceras*. One vertical section apparently shows canals radiating from the central parts of the siphuncle toward its exterior walls, as in the Actinoceratidae, or at least as in the Cyrtochoanites. Hence this genus was placed by Troedsson among the Actinoceratidae, although the lower margin of its septal necks does not curve strongly outward, as in typical members of that group.

The genus *Donacoceras*, proposed by Foerste[8] in 1925, is founded on a number of relatively large siphuncles which contract only slightly at the septal necks. These septal necks do not curve outward at their lower margins, and their structure apparently is similar to that of the Orthochoanites. The preservation of these

[7] Troedsson, Gustaf, Ibid., 1926, p. 77, pls. 45, 46.

[8] Foerste, Aug. F., Cephalopoda of Lake Timiskaming area and certain related species; in Hume, G. S., The Palaeozoic outlier of Lake Timiskaming, Ontario and Quebec, Memoir 145, Geol. Surv. Canada, 1925, p. 68, pl. 10.

siphuncles, in the absence of the septa and shell of the conch, is due apparently to a slight thickening of their walls by the deposition of a thin layer of calcareous material on their interior, but this deposit is very thin, not exceeding a third of a millimeter in the specimens studied.

Although the three genera, *Narthecoceras*, *Calhounoceras*, and *Donacoceras* present siphuncles with a somewhat similar appearance externally, they appear to belong to distinct suborders and are discussed here chiefly because Troedsson definitely referred *Narthecoceras* to the Endoceratidae and *Calhounoceras* to the Actinoceratidae, and it is desired here to call attention both to those structures which favor such a correlation and those which present difficulties.

Incidentally it should be noted that the genotype of *Deiroceras*, namely the species described by Billings under the name *Orthoceras python*, also occurs chiefly in the form of siphuncles, free from the remainder of the conch, the latter being rarely preserved. The segments of the siphuncles referred to this species sometimes are somewhat elongated, but nothing definite is known at present concerning their septal necks.

With the preceding observations in mind, the families here adopted may be defined as follows:

The term Actinoceratidae is restricted here to forms in which the septal necks are relatively long, so that the brim of these necks is conspicuously removed from contact with the septum from which this neck originates. In this family the segments of the siphuncle are strongly nummuloidal, their width exceeding their length.

In the Armenoceratidae are included all forms with broad nummuloidal segments of the siphuncle and with very short septal necks, the length of the latter often not exceeding twice the thickness of a septum. The brim of these necks may extend outward from the septal foramen for a short or a longer distance, but is always present. In some genera the upper surface of the brim is in contact with the lower surface of the septum from which it originates for either a part or the whole of the width of this brim. In others, however, for instance in the genotype of *Armenoceras*,

originally described by Parks as *Actinoceras hearsti*,[9] the brim of the septal necks is free from contact with the overlying septum, though the septal necks are very short. There is always an area of adnation between the lower face of each connecting ring and the upper surface of the underlying septum.

In the Huroniidae the septal necks are extremely short, as in the Armenoceratidae, but there is almost no area of adnation between the lower surface of the septa and the upper face of the immediately underlying connecting ring. On the other hand, the area of adnation between upper surface of these septa and the lower part of the overlying connecting ring often is extremely long, extending upward sufficiently to include the lower face of the annular enlargement of the upper part of this ring. In *Huronia* the segments of the siphuncle have the form of inverted pestles. In *Huroniella* there is a somewhat similar annular enlargement of the upper part of the segments of the siphuncle, but the lower, narrower part is of very much shorter length. This lower part of the segments is still shorter in *Discoactinoceras*[10] Kobayashi, but apparently the outline is similar to that of *Huroniella*. Very little about this genus is known, and its structure can be surmised only from a diagrammatic section given on page 201 of Kobayashi's[11] paper. Although Kobayashi does not mention such a structure, there apparently is a recurvature of the septa at their inner margin, and the resulting brim is in rather close contact with the lower side of the overlying septa. From the brim the connecting ring rises, but apparently does not come in contact with the lower side of the overlying septum. However, the area of contact between the connecting ring and the upper side of the underlying septum is rather broad. Judging from this structure the genus *Discoactinoceras* belongs in the family Huroniidae, along with *Huronia* and *Huroniella*.

In the Sactoceratidae the septal necks have a structure some-

[9] Foerste, Aug. F., Ordovician and Silurian cephalopods of the Hudson Bay area, Jour. Sci. Lab., Denison Univ., vol. 22, 1927, p. 68, pls. 8, 24.

[10] Kobayashi, Teiichi, Ordovician Fossils from Corea and south Manchuria. Japanese Jour. Geol. Geog., vol. 5, 1926–27, p. 200, pl. 22, figs. 7a–d.

[11] Kobayashi, T., Ibid., 1926–1927, p. 201, text-figure 6.

what similar to those of the Actinoceratidae, but on a smaller scale. The siphuncles usually are smaller, compared with the diameter of the conch, and the lateral diameter of their segments usually does not exceed their length, so that the form of these segments usually is approximately globular, though moderately elongated in a vertical direction in some specimens of *Deiroceras*. Usually the calcareous deposits within the siphuncle are moderate in quantity and in some specimens may even be absent. Rarely they extend sufficiently into the interior of the siphuncle to constrict the latter into a narrow central tube or endosiphuncle.

In the Gonioceratidae the conchs are strongly flattened dorsoventrally and narrowed laterally so as to present lenticular transverse cross-sections. The sutures of the septa curve strongly and broadly downward along the median parts of both the dorsal and the ventral faces of the conch, but curve more or less distinctly outward along the lateral margins of these lobes. In *Gonioceras* this outward curvature continues sufficiently to produce broad and conspicuous saddles along the lateral parts of both the dorsal and the ventral faces of the conch; but in *Lambeoceras*, this outward curvature of the sutures continues only for a short distance, so that there are no saddles except along the more or less angular lateral margins of the conch, where the sutures of the septa pass from the dorsal to the ventral face of the latter. In both *Gonioceras* and *Lambeoceras* the segments of the siphuncle are broadly nummuloidal, but their septal necks differ greatly in structure, as is well shown by the illustrations presented by Troedsson.[12] In *Gonioceras* these necks are short and their brims are strongly recurved. In *Lambeoceras* the lower margin of the septal necks appears widened and implanted on the upper margin of the underlying connecting ring. The brim or recurved part of these necks extends outward for a much shorter distance from the septal neck than in *Gonioceras*, but this outward curvature nevertheless is sufficient, in our opinion, to indicate the relationship of this genus to the Cyrtochoanites rather than to the Orthochoanites.

For the classification of the Annulosiphonata we suggest their

[12] Troedsson, Gustaf, Ibid., 1926; Gonioceras: pls. 2, 48, 53; Lambeoceras, pls. 2, 21, 22, 25; Huronia, pl. 36; Thuleoceras, pl. 55.

division into the following families, including only those genera whose structure is sufficiently understood to warrant an attempt at their assignment to a definite family:

*Actinoceratidae*
- Actinoceras Bronn
- Kochoceras Troedsson
- Leurorthoceras Foerste
- Paractinoceras Hyatt
- Rayonnoceras Croneis
- Saffordoceras Foerste and Teichert
- Troostoceras Foerste and Teichert

*Armenoceratidae*
- Armenoceras Foerste
- Cyrtactinoceras Hyatt
- Discosorus Hall
- Elrodoceras Foerste
- Megadiscosorus Foerste
- Nybyoceras Troedsson
- Selkirkoceras Foerste
- Stokesoceras Foerste
- Westonoceras Foerste

*Huroniidae*
- Huronia Bigsby
- Huroniella Foerste
- Discoactinoceras Kobayashi

*Sactoceratidae*
- Sactoceras Hyatt
- Eskimoceras Troedsson
- Troedssonoceras Foerste
- Ormoceras Stokes
- Deiroceras Hyatt

*Gonioceratidae*
- Gonioceras Hall
- Lambeoceras Foerste

The genus *Thuleoceras* Troedsson belongs to the Armenoceratidae, but is not included in this list because it appears to be a synonym of *Westonoceras*. The genus *Stereoplasmoceras* Grabau[13] apparently belongs to the Armenoceratidae, judging from the published vertical section of the conch passing through the siphuncle. According to this figure the segments of the siphuncle are vertically depressed, the intermediate septal necks being very short. Calcareous deposits of an actinoceroid type fill all but the central part of the siphuncle, and tubuli extend from the central endosiphon laterally toward the walls of siphuncle slightly above midheight of its segments. In general, the structure of this siphuncle appears similar to that of *Armenoceras*, but the size of this siphuncle is distinctly smaller, compared with the diameter of the conch, than in typical *Armenoceras*. How close this relationship is can not be determined until the structure of the septal necks of this genus is better known. The genus was based on the presence of pseudosepta within the camerae, with stereoplasmic calcareous

[13] Grabau, Amadeus, Ordovician Fossils from North China, Palaeontologia Sinica, ser. B, vol. 1, fascicle 1, 1922, p. 65, pls. 6, 9.

deposits between the pseudosepta and the normal septa. We doubt the validity of a genus based on the presence or absence of pseudosepta.

In establishing his genus *Rayonnoceras*, Croneis[14] defines it as possessing "camerae completely filled by a uniform deposit secreted by the rayonnettes of the endosiphuncle, which terminate at the outer shell of the animal rather than at the outer margin of the siphuncle. Siphuncle large, solid throughout, and strongly corrugated longitudinally, except on the ventral side." How the rayonnettes of the endosiphuncle are able to pass the walls of the siphuncle is not stated. Our own conception of this genus is based on the structure of the walls of the siphuncle, especially on that of its septal necks.

The following pages are devoted to a study of those actinoceroids which during a course of many years have accumulated at the U. S. National Museum. These have had a varied history. In some of the earlier collections no exact horizon was recorded on the accompanying labels, and in a few even the locality from which they were obtained was not indicated. All such were submitted to Dr. R. S. Bassler, whose wide acquaintance with American Paleozoic strata solved most of our difficulties. We were assisted also most liberally by Dr. E. O. Ulrich who had collected many of the more recently acquired specimens.

The list of species at the beginning of this paper serves not only as an index, but includes also information as to the state from which they were obtained, and as to the horizon in which they were found. In the following list these are arranged so as to bring together those species which come from the same horizon. Where this horizon is more or less uncertain, the customary question mark is used. No attempt is made to include also the names of those horizons from which no cephalopods are described here. Detailed information as to the subdivisions into which American Ordovician and Silurian formations have been divided is given in the tables at the close of Bassler's Bibliographic Index of American Ordovician and Silurian Fossils, published in 1915.

[14] Croneis, Carey, New cephalopods from the Fayetteville shale, Bull. Mus Comp. Zool., vol. 67, 1926, p. 343, pls. 1, 2.

*Vertical distribution of cephalopods here described*

I. Mississippian
Rayonnoceras bassleri; Fayetteville (?)
Rayonnoceras buffaloense; St. Louis (?)
Rayonnoceras girtyi; St. Louis (?)
Rayonnoceras vaughanianum; St. Louis (?)
Rayonnoceras cf. vaughanianum; St. Louis (?)

II. Silurian
Elrodoceras telleri; Racine
Elrodoceras osmanense; Dayton

III. Ordovician
A. Richmond
Armenoceras madisonense; Saluda
Armenoceras richardsoni; Selkirk
Deiroceras dismukesense; Richmond
Westonoceras cf. iowense; Red River, possibly upper Trenton.

B. Maysville
Ormoceras covingtonense

C. Trenton
Westonoceras iowense; Stewartville
Westonoceras cf. manitobense; Stewartville
Westonoceras sp.; Stewartville

Armenoceras brevicameratum; Catheys
Deiroceras capitolense; Catheys (?)
Deiroceras nashvillense; Catheys
Ormoceras troosti; Catheys
Saffordoceras nelsoni; Catheys

Actinoceras caneyense; Cannon (?)
Actinoceras lentiexpandum; Cannon
Ormoceras cannonense; Cannon
Ormoceras lindsleyi; Cannon

Actinoceras capitolinum; Bigby
Deiroceras capitolense; Bigby (?)
Troostoceras paulocurvatum; Bigby
Troostoceras paulocurvatum abbreviatum; Bigby (?)

Deiroceras python; undifferentiated Trenton

Actinoceras curdsvillense; Curdsville
Deiroceras curdsvillense; Curdsville

Deiroceras richteri; Prosser.

D. Black River
Actinoceras beloitense; not differentiated
Actinoceras bigsbyi; not differentiated

Westonoceras (?) rallsense; Kimmswick

Actinoceras centrale; Watertown
Actinoceras ruedemanni; Watertown
Actinoceras tenuifilum; Watertown

Actinoceras (?) lindenense, undifferentiated Lowville

Actinoceras paquettense; Leray

Actinoceras altopontense; Tyrone
Actinoceras arcanum; Tyrone
Actinoceras beloitense; Tyrone
Actinoceras bigsbyi; Tyrone
Actinoceras caneyense; basal Tyrone (?)
Actinoceras glenni; Tyrone (?)
Actinoceras jessaminense; Tyrone
Actinoceras kentuckiense; Tyrone
Ormoceras ferecentricum; Tyrone
Ormoceras normanense; Tyrone

Actinoceras pohli; Carters
Actinoceras saffordi; Carters
Actinoceras cf. saffordi; Carters
Actinoceras tennesseense; Carters (?)

Actinoceras adnatum; Plattin
Actinoceras cinctum; Plattin
Actinoceras circulare; Plattin
Actinoceras glencoense; Plattin

Actinoceras bigsbyi; Platteville

Actinoceras bellefontense; lower Lowville

E. Chazyan
Actinoceras libanum; Lebanon
Leurorthoceras altopontense; Lebanon
Leurorthoceras lebanonense; Lebanon

Nybyoceras ulrichi; Simpson

The exact horizon of the species of *Rayonnoceras* mentioned in the preceding list is not known, beyond the fact that they appear to be of Mississippian age.

The Racine belongs to the Lockport division of the Niagaran or middle Silurian. The Dayton limestone is the oldest part of the Clinton exposed in Ohio.

The Saluda is the uppermost Richmond exposed in southeastern

Indiana, along the Ohio River, but farther north it wedges into the Whitewater member of the Richmond. The Selkirk limestone is the uppermost part of the Red River formation[15] in southern Manitoba. It is overlaid by the Stony Mountain formation. Both formations are referred tentatively to the Richmond, but the Red River formation possibly may be Trenton. The equivalents of the Red River formation occur widely distributed in the American Arctic, occurring as far north as northern Greenland and as far east as southern Baffin Island. The specimens of Westonoceras found on Akpatok Island are assumed to have come from some equivalent of this Red River formation.

The Stewartville dolomite long was regarded as the uppermost member of the Trenton as exposed in Minnesota and northern Iowa. Recently its affinities to the Red River formation have been recognized, but its more exact correlation will require further study.

In central Tenneessee, the Catheys formation is the uppermost member of the Trenton. It is underlaid by the Cannon limestone, and this in turn by the Bigby. The Cannon is a fine-grained dove-colored limestone, the Catheys and the Bigby consisting of coarser-grained limestones. The Curdsville forms the basal member of the Trenton as exposed in central Kentucky. Its fauna is similar to that occurring in the Hull limestone of southern Kentucky, and in part of the Prosser of the northern Mississippi valley.

The Kimmswick has long been referred to the uppermost part of the Black River, as exposed in southeastern Missouri and in the adjacent part of southern Illinois. The Watertown limestone forms the upper part of the Black River as exposed in north-central New York. It is underlaid here by the Lowville. The Platteville of the northern Mississippi Valley and the Plattin of Missouri and Illinois are regarded as approximately equivalent to the Lowville of New York. The Lowville, using this term in its broader sense, includes the Leray of New York and southern Ontario, the Tyrone of Central Kentucky, and the Carters of

[15] Foerste, Aug. F., The cephalopods of the Red River formation of Southern Manitoba, Jour. Sci. Lab., Denison Univ., vol. 24, 1929, pp. 130, 136.

central Tennessee, these three limestones forming an approximately descending series within the Lowville.

The Lebanon limestone occurs directly beneath the Carters in central Tenneessee, and is the uppermost member of the Stones River division of the Chazyan as exposed in that state. In central Kentucky, the upper half of the Camp Nelson formation is correlated with the Lebanon. The Simpson formation of Oklahoma includes not only the Lebanon limestone but all the underlying members of the Stones River as exposed in Tennessee.

Among the species described in the present paper almost half came from the various members of the Black River, and by far the greater part of the latter came from the Lowville and its various equivalents. Slightly more than three-tenths of the total came from the Trenton. The remainder are from the Chazyan, Maysville, Richmond, Silurian, and Mississippian, none of these divisions being rich in actinoceroids. Most of the species here described, about two-thirds of the total, came from Tennessee, Kentucky, and Missouri, with Tennessee leading this list, fully one-third of the total number of species described coming from that state.

The genus *Actinoceras* is represented by the greatest number of species in the Black River and Trenton divisions of the Ordovician, but it is known also from the Richmond of Anticosti Island, in the Gulf of St. Lawrence. Here *Actinoceras anticostiense* (Billings) and *Actinoceras carletonense* Foerste[16] occur in the English Head member of the Richmond. *Actinoceras serum* Foerste was described from the Chicotte member of the Clinton division of the Silurian. Its occurrence at this upper horizon is extremely puzzling, but is matched by the occurrence of the holochoanitic species *Cameroceras vantuyli* Foerste[17] in the Severn River member of the Silurian in the area southwest of Hudson Bay. Both genera are known from Silurian strata only in northern areas,

[16] Foerste, Aug. F., The cephalopod fauna of Anticosti, in Twenhofel, W. H., Geology of Anticosti Island, Memoir 154, 1928, pls. 41, 42, 43, 33; Some hitherto unfigured Ordovician cephalopods from Anticosti Island, Trans. Royal Soc. Canada, 3rd ser., vol. 22, sec. 4, 1928, pls. 4, 5.

[17] Foerste, Aug. F., Ordovician and Silurian cephalopods of the Hudson Bay area, Jour. Sci. Lab., Denison Univ., vol. 22, 1927, p. 29, pl. 2, fig. 2.

where apparently they survived for a long time after they had disappeared from more southern waters.

On the eastern side of the Atlantic, *Actinoceras* is known only from Bear Island, halfway between the northern end of Norway and Spitzbergen, where it occurs associated with *Gonioceras nathorsti* Holtedahl[18] in strata equivalent to the Black River of North America. *Armenoceras,* on the contrary, begins its vertical range in the Catheys member of the Trenton and continues thence upward into the Richmond and the Silurian. In northwestern Europe it is known only from the Silurian, occurring in Gotland, Esthonia, and England. The species described by Barrande[19] from the Silurian of Bohemia as *Orthoceras docens,* is an actinoceroid beginning with broad nummuloidal segments of the siphuncle with short septal necks as in typical *Armenoceras,* narrowing to segments of more globular form farther up.

In general it may be stated that very few of the genera of actinoceroids range from the Ordovician into the Silurian, and none are known to range from the latter into the Devonian.

In the study of cephalopods certain procedures have been found convenient. The conchs usually are supposed to be oriented in a vertical position, with the smaller end at the base; not because the conch is supposed to have been carried by the living animal in that position, but because in that position most of the features of the conch, both externally and interiorly, photograph well. Then any direction toward the smaller end of the conch is called *down,* and any direction toward the living chamber is called *up.* Measurements parallel to this vertical axis are recorded as either *length* or *height,* while measurements transverse to this vertical axis are recorded as *width.*

The relative number of camerae in a conch is recorded as so many camerae in a length equal to the diameter of the conch, this diameter invariably being measured at the *top* of the series of camerae counted. In case the dorsoventral diameter differs from

[18] Holtedahl, Olaf, On the Paleozoic series of Bear Island, especially on the Heclahook system, Norsk Geologisk Tidsskrift, vol. 5, p. 132, pl. 14.

[19] Barrande, Joachim, Systeme silurien du centre de la Boheme, vol. 2, 1868, 1874, pl. 250.

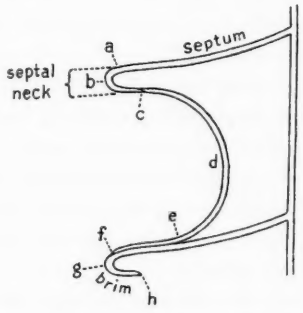
the lateral one in length, the dorsoventral one is used in preference, because a dorsoventral section of the conch exposes also the siphuncle so that this ordinarily is the most useful direction for measurements of all kinds of structures. However, in some conchs, for instance in those of the actinoceroids, the dorsal side rarely is well preserved, while the ventral side often is sufficiently well preserved to determine their lateral diameter. In those cases the lateral diameter is employed. While it is true that the number of camerae often varies within the length of the same conch, this number usually is fairly constant at the same stages of growth. Therefore it is important that the diameter of the conch at which the number of camerae was determined be recorded, indicating also which diameter was employed, unless the two diameters are essentially equal. Since at so-called gerontic stages of growth of the conch the height of the camerae usually shortens in a manner differing greatly in different individuals, these shorter upper camerae should not be included in any estimate of the relative number of camerae present.

In a similar manner, the ratio of the diameter of the siphuncle to that of the conch often varies along the length of the same conch, so that it is advisable to record both measurements at different locations along the conch unless this ratio is constant. Since a dorsoventral diameter of the conch also passes through the center of the siphuncle, it is preferable to use this diameter of the conch in recording measurements of the siphuncle.

Since the downward curvature of the septa of most cephalopods is fairly uniform, their relative concavity can be indicated sufficiently by recording their vertical depth at their centers below their lateral margins. In those cases where their curvature is not uniform a more detailed description may be advisable.

In those conchs in which the septal necks are not continuous from neck to neck, but are confined to the upper parts of the segments of the siphuncle, so that consecutive necks are connected together by connecting rings, the relative length of the necks to the rings should be recorded. It is important, moreover, to discover precisely where the margins of the septal necks terminate and where the immediately adjacent parts of the connecting rings

begin; how much the lower parts of these necks flare outward, and whether this flaring part of the neck is free from contact, or is adnate to the lower surface of the septum from which the septal neck originates. In those conchs in which the upper side of the septa is adnate to the lower face of the overlying connecting rings the area of adnation should be measured radially, from the most contracted part of the septal foramen outward, and expressed as the *width* of this area.




STRUCTURE OF PART OF SEGMENT OF AN ACTINOCEROID SIPHUNCLE

*a–c*, septal neck; *g–h*, brim; *c–f*, connecting ring; *c–e*, free part of ring; *e–f*, area of adnation.

In these studies it is convenient to use the term *septal neck* for the entire length of the constricted part of the septum in the vicinity of the siphuncle. Its length is measured vertically downward from that part of the septum which begins to curve downward beneath the general concave curvature of the septum as a whole to the lowest part of the neck present. In the Cyrtochoanites the term *brim* is applied to the lower half of the neck, extending from the most contracted part of the septal foramen outward as far as the junction of this neck with the top of the connecting ring beneath. The area of contact between the lower surface of a connecting ring and the immediately underlying septum is called its *area of adnation*. Both the brim and this area should be measured radiately outward from the most contracted part of the septal foramen and expressed as the *width* of the brim or area of

adnation. A similar area of adnation sometimes occurs between the lower face of the septum and a larger or smaller part of the width of the immediately underlying brim. That part of the lateral sides of the connecting rings which remains free from adnation to either the underlying or overlying septa is called their *free* part.

In the Annulosiphonata deposits of calcareous material begin on the inner surface of the septal necks and grow increasingly inward, at the same time expanding upward and downward. As a result these deposits take an annular form, known by some writers as the annuli. In the older parts of siphuncles these annuli usually meet a little above midheight of the camerae, leaving an irregular tube-like cavity known as the *endosiphuncle.* Lateral extensions of this endosiphuncle often include horizontal tube-like rays, known as tubuli. These usually form parts of a very thin horizontal layer between the successive annular deposits mentioned above, and terminate, therefore, a little above midheight of the segments of the siphuncle.

Recent observations have indicated the necessity of a more exact study of the structure of the septal necks of siphuncles and of the deposits within their interior than hitherto attempted. Indications are that more intensive researches along these lines will result in a very marked progress in our knowledge of the Annulosiphonata. Unquestionably new terms and new procedures will result from such studies, but the preceding observations will serve to indicate those used in the present publication.

## ACKNOWLEDGMENTS

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Finally, we also desire to express our great indebtedness to Mrs. Trude Teichert, the wife of the junior author, for her very conscien-

tious and successful efforts in photographing the cephalopods here studied and in preparing these photographs for publication. The difficulties presented in securing satisfactory views of the internals structures of the siphuncles, as well as in securing adequate representations of their exteriors have been fully overcome, and the results make possible the accompanying plates.

## ACTINOCERAS Bronn

Genotype: *Actinoceras bigsbyi* Bronn, Lethaea Geognostica, vol. 1, 1837, p. 97–98, pl. 1, fig. 8; Foerste, Contrib. Mus. Geol., Univ. Michigan, vol. 2, 1924, p. 31, pl. 1, figs. 1A, B; 2.

Typical *Actinoceras* is characterized by its relatively large siphuncle, located near the ventral wall of the conch. The segments of its siphuncle are broadly nummuloidal in form, except at gerontic stages of growth, where, in certain species, these segments become much narrower and even vertically elongated. The septal necks are relatively long. The ventral side of the conch usually is more or less flattened or at least less strongly curved than the ventral side. The sutures of the septa usually curve distinctly downward ventrally.

The genus *Conotubularia*, proposed by Troost (Mem. Soc. Geol. France, vol. 3, 1838, p. 87) is strictly congeneric with *Actinoceras*, described one year earlier. The species described first under *Conotubularia* is *Conotubularia cuvierii*, from the lower strata exposed along the Cumberland River at Nashville, Tennessee (Ibid., pl. 9, fig. 1), and this species is regarded as the genotype. Judging from the published figure, the segments of the siphuncle became distinctly narrower toward the upper end of the conch, and the intervening necks were relatively long. The second species, *Conotubularia brongniarti*, is stated to have an annulated siphuncle, evidently near the ventral side of the conch. It probably was related to the same group as *Actinoceras tenuifilum*, but the details of its structure are lacking. It also came from the lower strata along the Cumberland River, at Nashville. The third species, *Conotubularia goldfussi*, from St. Cloud's hill, at Nashville, at a level at least 100 feet higher than the two preceding, apparently also is a typical form of *Actinoceras*.

The genus *Kochoceras*, proposed by Troedsson, differs from *Actinoceras* chiefly in the strong dorsoventral compression of the conch, and the strong flattening of its ventral side, as illustrated by *Kochoceras cf. tyrrelli* Foerste (Plate LVIII, fig. 11).

### 1. **Actinoceras adnatum** Sp. nov.

*Plate XXXIX, figs. 3A, B, C*

Specimen 68 mm. long, including only the siphuncle and the median part of the ventral wall of the conch. The basal segment of the siphuncle is represented only by its upper part, above the level of the so-called tubuli. The dorsoventral diameter enlarges from 19.5 mm. at its lowest segment to 21.5 mm. at its third segment and 23 mm. at the sixth. The lateral diameter at the third segment is 24 mm., diminishing slightly to 23 mm. at the overlying three segments. There are 2.6 segments in a length equal to the diameter of the siphuncle. The lower face of these segments curves diagonally downward and inward as far as the septal necks which are about 1.5 mm. long. The areas of contact of the segments of the siphuncle with the ventral wall of the conch vary from 25 mm. in width at the third well preserved segment to 18 mm. at the uppermost segment.

Occurrence.—Glencoe, Missouri; in the upper part of the Plattin or Lowville division of the Black River. Holotype; no. 82191; U. S. National Museum.

Remarks.—*Actinoceras adnatum* differs from *Actinoceras cinctum* chiefly in the broad contact of the siphuncle with the wall of the conch along the ventral part of the specimen. Such a contact also appears in *Actinoceras glencoense*, but is much narrower here, and only a very slight flattening of the siphuncle takes place in the latter species. Another difference is the shortness of the septal necks in *Actinoceras glencoense* in comparison with those of *Actinoceras adnatum*.

### 2. **Actinoceras altopontense** Sp. nov.

*Plate XXXV, figs. 1A, B, C; plate LVI, fig. 1*

Specimen 97 mm. long, enlarging at an angle of 10 degrees laterally. At its top the lateral diameter is 51.5 mm. and its dorsoven-

tral one is estimated at 47.5 mm. The ventral side of the conch is slightly flattened. Six and a half camerae occupy a length equal to the diameter of the conch at the top of the series counted. The sutures of the septa curve downward ventrally about 5 mm. below their level dorsolaterally at the top of the specimen. The concavity of the septa is 5 mm. where the diameter of the conch is 47 mm. The connecting rings are in contact with the ventral wall of the conch for a width of 17 mm. at the base of the specimen, but apparently are in contact for only half this width or even less at its top. The diameter of the siphuncle enlarges from 25 mm. at the base of the specimen to 26 mm. at its top, its diameter being essentially constant within the length preserved. Since the conch enlarges much more rapidly than the siphuncle, the ratio between the two is not constant. Where the diameter of the conch is 40 mm. the ratio of the diameter of the siphuncle to the latter is 62.5, changing to 51 where this lateral diameter of the conch is 51 mm. Three and a half camerae occur in a length equal to the diameter of the siphuncle. Where the camerae are 7 mm. in height, the length of the septal necks is 1 mm.

Occurrence.—High Bridge, Kentucky; in the Tyrone member of the Lowville, just beneath the green clay layer exposed in the quarry. Holotype; no. 82196; U. S. National Museum.

Remarks.—*Actinoceras altopontense* can be compared with *Actinoceras glenni*, but the septal necks are longer in the latter species and the rate of enlargement apparently was smaller. Moreover, the sutures of the septa of *Actinoceras glenni* curve downward more rapidly than those of *Actinoceras altopontense*.

### 3. **Actinoceras arcanum** Sp. nov.

*Plate XXXIX, figs. 1A, B; plate LVI, fig. 3*

This species evidently belongs to the same group as *Actinoceras tenuifilum*, but differs in the distinct contact of the segments of the siphuncle with the ventral wall of the conch even above the level at which the siphuncle contracts conspicuously. Moreover, the downward curvature of the sutures of the septa ventrally is less conspicuous than in most other species of this group.

Specimen 66 mm. long, preserving most of the ventral side of

the conch. Its original lateral diameter is estimated at 50 mm., the median part of its ventral side being somewhat flattened. Six camerae occupy a length of 52 mm., the lowest of this series being 8 mm. long, while that at the top measures 10 mm. The sutures of the septa curve downward ventrally at least 5 mm. At the lower end of the specimen, where the lateral diameter of the siphuncle is 30 mm., the area of contact of the segment with the ventral wall of the conch is 15 mm. wide and 3.5 mm. high. Five segments farther up, where the diameter of the siphuncle is 23 mm., the corresponding area of contact is only 9 mm. wide.

Occurrence.—High Bridge, Kentucky; in the Tyrone member of the Lowville. Holotype; U. S. National Museum; no. 82238.

Remarks.—*Actinoceras arcanum* bears some resemblance to the specimen described on a following page as *Actinoceras cf. saffordi*, but the siphuncle of the former decreases more rapidly in size. Moreover, in *Actinoceras cf. saffordi* the septa curve downward even less than in *Actinoceras arcanum*. Another species to be compared with *Actinoceras arcanum* is *Actinoceras pohli*. However, in this case the resemblance consists chiefly in a similarity of the general outline of the siphuncle, this siphuncle not being in contact with the ventral wall of the conch in the latter species.

### 4. **Actinoceras bellefontense** Sp. nov.

*Plate XXXVIII, figs. 2A, B; plate LVI, fig. 4*

Specimen closely similar to *Actinoceras tenuifilum*, but not attaining as large a size, and not enlarging as rapidly either dorsoventrally or laterally.

Specimen 85 mm. long, enlarging laterally from a diameter of 37 mm. at its base to 49 mm. at a point 70 mm. farther up. The corresponding dorsoventral diameters are 30 mm. and 35 mm. Five camerae occur in a length of 35 mm. at the lower end of the same specimen while the same number has a total length of 37 mm. farther up. At the base of the specimen the dorsoventral diameter of the siphuncle is 19 mm. decreasing to 18.5 mm. at the fourth segment from its base, but from this point it decreases more rapidly to 11 mm. at the eighth segment, and then more slowly to 10 mm. at the eleventh. The siphuncle is not in con-

tact with the ventral wall of the conch along any part of the specimen preserved. Its distance from this wall increases from 0.7 mm. at the base of the specimen to 1.5 mm. at the fourth segment and to 4.5 mm. at the eleventh. The septal necks have a length of a little less than 2 mm. at the lower end of the specimen, increasing to distinctly more than 2 mm. at its top. In a dorsoventral section through the center of the conch, the septa appear relatively straight, as in *Actinoceras tenuifilum*, rising at about the same angle in a dorsad direction. On the dorsal half of the conch the sutures of the septa slope downward in a ventrad direction at a small angle with the horizontal, but this angle increases conspicuously on the ventral half of the conch, the downward curvature equalling about 5 mm. along the upper part of the specimen.

Occurrence.—Bellefonte, Pennsylvania; in the basal part of the Lowville member of the Black River. Holotype; U. S. National Museum; no. 82204.

Remarks.—The most characteristic feature of *Actinoceras bellefontense* is the rapid decrease in diameter of its siphuncle toward the top of the specimen. In this respect it closely resembles those forms distinguished by Foerste as *Leurorthoceras*. However, in its earlier stages of growth the siphuncle of the species here under discussion so closely resembles that of typical *Actinoceras* that it does not seem advisable to refer this species to *Leurorthoceras*, at least until the generic validity of *Leurorthoceras* has been subjected to further study.

### 5. **Actinoceras beloitense** (Whitfield)

*Plate XXVIII, fig. 2; plate XXIX, fig. 1; plate XXX, figs. 1A, B; plate LIX, fig. 7*

*Orthoceras* (*Actinoceras*) *Beloitense* Whitfield, Geol. Wisconsin, vol. 4, p. 226, pl. 8, fig. 1, 1882.

Cf. *Orthoceras fusiforme* Hall, Pal. New York, vol. 1, p. 60, pl. 20, fig. 1, 1847 (not Sowerby, 1828).

Cf. *Gomphoceras hallii* D'Orbigny, Prod. Pal., vol. 1, p. 3, 1850.

Specimen 485 mm. long, the living chamber occupying 145 mm. of this length. The lateral diameter enlarges from 27 mm. near its base to 110 mm. at the base of the living chamber. The living

chamber contracts toward the aperture, but the exact amount of this contraction can not be determined. The median part of the dorsal side is not preserved, but enough remains to suggest that the cross-section of the conch was elliptical, with no distinct flattening of its ventral transverse outline, compared with its dorsal one. Where the lateral diameter of the conch is 84 mm. its dorsoventral one is estimated at 65 mm. The number of camerae in a length equal to the lateral diameter of the conch at the top of the series counted equals 6 along the lower half of the phragmacone up to a point where this lateral diameter is 70 mm. Then their number increases to 7 camerae where this diameter equals 100 mm. At this level the camerae are 12 mm. in height. The fifth camera above this level is 10 mm. in height, the next is 7.5 mm. tall, and the last three total only 12.5 mm. The sutures of the septa slant downward from the lateral sides in a ventrad direction, their downward curvature equalling almost 10 mm. at its maximum. However, on approaching the lateral outlines of the conch these sutures curve slightly outward, in a faintly sigmoid manner. The septa rise distinctly higher dorsally than ventrally. The siphuncle is located close to the ventral wall of the conch along the lower part of the specimen, probably less than 1 mm. away, and possibly in bare contact in some of its lower segments. However, where the lateral diameter of the conch is 65 mm. the siphuncle is 2.5 mm. from the ventral wall, and where the diameter is 95 mm. this distance is 10 mm. Above this point the connecting rings of the siphuncle are not preserved, but it is assumed that the distance of these rings from the ventral wall continues to increase. Where the lateral diameter of the conch is 60 mm. the center of the siphuncle, at its passage through the septa, is 14 mm. from the ventral wall of the conch. This distance increases to 16 mm. farther up, and continues at this distance at least as far as the base of the fourth camera beneath the living chamber. From this it is evident that the center of the siphuncle remains at almost the same distance from the ventral wall of the conch and that its apparent increased distance is due to a decrease in the lateral diameter of its segments, especially of its connecting rings. Where the lateral diameter of the conch is 60 mm. the dorso-

ventral diameter of the connecting rings is 22 mm., decreasing to an estimated diameter of 12 mm. where the diameter of the conch is 100 mm. Above this point the diameter of the siphuncle can not be determined. The form of the segments of the siphuncle changes from depressed nummuloidal below to nearly globular at the highest level at which their outlines are preserved. At mid-length of the phragmacone the septal necks are about 2.5 mm. in length where the height of the camerae is 13 or 14 mm. Their lower margin curves strongly outward. The lower part of the connecting rings comes in contact with the septa at the point where these septa curve downward so as to form the septal necks. The surface of the shell appears to have been smooth. U. S. National Museum; no. 82225.

A second specimen from the same locality is 450 mm. long and attains a lateral diameter of 105 mm. at the base of the living chamber. This chamber is 175 mm. long and contracts to a lateral diameter of 86 mm. at its aperture, the rate of contraction being slightly less along its upper 50 mm. of length. Along the lower part of the phragmacone the height of the camerae is distinctly less than at mid-length, as in the specimen figured by Whitfield and cited above. U. S. N. M.; no. 82226.

A third specimen, also from the same locality, 100 mm. long and originally over 103 mm. wide, retains the upper 10 camerae with a trace of an overlying eleventh camera. The lower 3 camerae average 12 mm. in length while the upper three average less than 3 mm. each. The connecting ring of the fourth segment of the siphuncle above the base of the specimen has a dorsoventral diameter of 10 mm., decreasing to 8 mm. in the upper three segments. In the case of these upper three segments, however, there is a return to the depressed nummuloidal form shown by the earlier segments of the siphuncle in other specimens. U. S. N. M.; no. 82203.

Occurrence: On the northwest side of Landspur, on the northeastern shore of St. Joseph Island, Lake Huron. In the Black River limestone.

U. S. National Museum; nos. 82225, 82226, 82203.

A closely similar specimen, numbered 5081 in the same museum, is from some unknown locality in the Black River of Wisconsin.

Another specimen was found 5 miles southeast of Shelbyville, Tennessee, in the Tyrone limestone, just under the upper bentonite bed. It is 435 mm. long, 112 mm. wide at the base of the living chamber, and of this chamber a length of 140 mm. is preserved. U. S. National Museum; no. 82236.

It can not be determined from the material at hand how closely similar *Actinoceras beloitense* is to the species described by Hall from the Black River of New York under the name *Orthoceras fusiforme*, since no specimens of the latter are at hand for sectioning, in order to learn the structure of its siphuncle.

Remarks.—The specimen figured by Clarke (The Lower Silurian Cephalopoda of Minnesota, Geol. Minnesota, vol. 3, pt. 2, 1897, pl. 47, fig. 18) as *Actinoceras beloitense* does not belong to this species, but apparently is a true *Actinoceras bigsbyi*. On the other hand, the larger specimen figured by him as *Actinoceras bigsbyi* is neither *Actinoceras bigsbyi* nor *Actinoceras beloitense*.

### 6. **Actinoceras bigsbyi** Bronn

*Plate XXVII, figs. 1A, B, C; plate XL, fig. 3; plate LVI, figs. 2, 5; plate LIX, fig. 6*

Orthoceras —— Bigsby, Trans. Geol. Soc. London, 1, p. 198, pl. 25, figs. 1, 2, and possibly 3, 1824.

Actinoceras bigsbyi Bronn, Lethaea Geognostica, vol. 1, p. 98, pl. 1, fig. 8, 1837.

Types.—The series of specimens of this species collected by Bigsby is preserved in the British Museum of Natural History in London. Three of these specimens he figured, and on these three Bronn based his genus and species *Actinoceras bigsbyi*.

The original of Bigsby's figure 1 is a single specimen (no. 33448), but broken into two parts. The entire specimen was 140 mm. long. At the break its lateral diameter is 37 mm. and its dorsoventral one is about 29 mm. The cross-section appears transversely elliptical, with the ventral side a little less convex than the dorsal. The diameter of the siphuncle here is 24 mm. laterally and 20 mm. dorsoventrally. Its ventral margin is near contact with the ventral wall of the conch. The base of the specimen

appears the lowest part of the species ever found preserved, and the septum here rises strongly in a dorsad direction. Where the conch is 40 mm. wide, 6 camerae occur in a length of 41 mm.

The original of Bigsby's figure 2 (no. C. 2664) is figured inverted. Of the original deposit filling the cavity in the interior of the siphuncle as figured by Bigsby, the lower part, 7 annulations in length, has broken off, and at present is missing. At the level of this break the lateral diameter of the conch is 51 mm. and that of the siphuncle is 29 mm. That part of the conch exposed probably is its ventral side. The rate of enlargement of the conch is uncertain, but its diameter appears to increase from 37 to 50 mm. in a length of 80 mm. In a second specimen on the same slab, the diameter of the conch appears to increase from 35 to 44 mm. in a length of 75 mm.

The original of Bigsby's figure 3 (no. C. 2668) represents the ventral side of a specimen with a lateral diameter of 55 mm. at its top. From this specimen it is evident that the ventral side of the conch was distinctly flatter than its dorsal one. The siphuncle at its annulations is about 1 mm. from the ventral wall of the conch. At 55 mm. below the level at which the lateral diameter was measured, the diameter of the siphuncle is 25 mm. Eight camerae occur in a length of 55 mm. where this also is the diameter of the conch. The sutures of the septa curve downward ventrally about 4 mm.; dorsally they either rise a little or are horizontal. The next larger specimen on the same slab as the last is 70 mm. in diameter. Its siphuncle here is 25 mm. in diameter at the septa, and probably 29 or 30 mm. at the annulations. The largest specimen on the same slab is at least 85 mm. in diameter laterally, and its siphuncle at this level is 20 mm. in diameter at the septum and probably is 25 mm. in diameter at the annulations. The siphuncle may become relatively smaller on approaching its top.

In the original of Foord's figure 20 (no. 26581), published in his Catalogue of Fossil Cephalopoda in the British Museum of Natural History, pt. 1, 1888, the enlargement of the conch is from 32.5 mm. to 43 mm. in a length of 50 mm. This is the best of the various measurements in which it was attempted to determine the rate of enlargement of the conch. This specimen exposes its

ventral side. The diameter of the siphuncle is 23 mm. where its distance from the ventral wall of the conch is 1 mm.

All of the preceding specimens are labelled as collected on Thessalon island, in Lake Huron. The rock matrix consists of a light brown dolomite, like that usually occurring in the Beloit member of the Black River in Wisconsin, and differs in this respect from the dense light blue limestone occurring in situ along the embayment indenting the northern margin of the island.

In his Notes on the Geography and Geology of Lake Huron (Trans. Geol. Soc. London, 2nd ser., vol. 1, 1824, p. 195), Dr. John J. Bigsby makes the following statement regarding the character of this rock:

The limestone of Thessalon Isle, in which the new species of orthoceratite (pl. XXV, figs. 1, 2, 3) is found, is decided magnesian; and in the compact parts of it has a saccharoid texture belonging to dolomite. Its cavities, and those of the organic remains, are lined with primitive rhomboids of the triple carbonate of lime and magnesia.

Additional references to the same specimens occur on pages 198 and 204. On page 198 there is a description of the deposits occurring in the interior of the siphuncle which shows that Bigsby fully appreciated the anomalous structure here becoming known for the first time.

Beloit specimen.—Specimen 100 mm. long, enlarging at an apical angle of 11.5 degrees laterally, the diameter at its base being estimated at 47 mm. in that direction. Where its lateral diameter is 55 mm., its dorsoventral one is 42.5 mm. The cross-section of the conch is elliptical, the ventral and dorsal sides having approximately the same degree of transverse curvature, compared with the more rapid transverse curvature of the lateral sides of the conch. About 7 camerae occur in a length equal to the lateral diameter of the conch. At midlength of the specimen the sutures of the septa curve downward about 10 mm. below their level laterally. Dorsally these sutures are directly transverse. The distance of the siphuncle from the ventral wall of the conch varies from 2 mm. along its lower part to 4 mm. farther up. The diameter of the connecting rings varies from 22 mm. at the

base of the specimen to 21 mm. within the fifth camera, 16 mm. in the eighth, and to an estimated diameter of 14 mm. within the tenth camera. The septal necks are about 2 mm. long on the dorsal side of the siphuncle, but more nearly 3 mm. in length ventrally. Their lower margins curve outward from 1 mm. along the lower part of the specimen to 1.5 mm. at its top. The contact of the lower face of the connecting rings with the underlying septa does not exceed 2 mm. in width.

Occurrence.—Beloit, Wisconsin; in the Platteville member of the Black River. Specimen no. 15669, U. S. National Museum. Another specimen from the same locality is numbered 82192.

A specimen closely resembling fig. 2 among those published by Bigsby was found at High Bridge, Kentucky, in the Tyrone member of the Lowville, and is numbered 82193 in the U. S. National Museum.

Remarks.—Many of the identifications of specimens with *Actinoceras bigsbyi* appear to be incorrect, the error being due to inadequate descriptions and figures of the type specimens. Satisfactory descriptions and figures must be based on further studies.

The specimen figured by Clarke[20] under *Actinoceras bigsbyi* from the Platteville of Rochester, Minnesota was included by Fenton[21] in his species *Actinoceras gravicentrum*, though his holotype of that species came from the Middle Plattin of Ste. Genevieve county, in Missouri. However, the specimen figured by Clarke on the same plate as *Actinoceras beloitense* (fig. 18) may be a true *Actinoceras bigsbyi*, although the siphuncle of the Minnesota specimen appears to be a little larger than the Wisconsin specimens here identified as *Actinoceras bigsbyi*.

In the case of *Actinoceras lyoni* (Stokes), placed by Bassler in his Index of 1915 in the synonomy of *Actinoceras bigsbyi*, the relative shortness of the septal necks of the former is a sufficient distinction from the latter species.

[20] Clarke, John M., The Lower Silurian Cephalopoda of Minnesota, Geol. Surv. Minnesota, vol. 3, pt. 2, 1897, pl. 47, fig. 17.

[21] Fenton, C. L., The Plattin formation of Ste. Genevieve county, Missouri, American Midland Naturalist, vol. 11, 1928, p. 138, pl. 2, fig. 9.

It will not be possible to clear up the synonomy of *Actinoceras bigsbyi* without a detailed study of the originals of the various specimens so identified.

### 7. **Actinoceras caneyense** Sp. nov.

*Plate XXXVII, figs. 1A, B; plate LVI, fig. 7*

Specimen 125 mm. long, enlarging at a lateral angle of 7 degrees. Its dorsoventral diameter probably is a little shorter than its lateral one, but there is no conspicuous flattening of its ventral side. The lateral diameter of the conch at its base is 32 mm. The suture of the septum at this point curves strongly downward ventrally, the septum itself rising dorsally. Below this septum a single segment of the siphuncle is preserved. This segment has a dorsoventral diameter of 17 mm.; at a point 55 mm. farther up the diameter of the siphuncle is 19.5 mm., and after an additional interval of 55 mm. it is 21 mm. No decrease in the diameter of the siphuncle is noted in the length preserved. The distance of the siphuncle from the ventral wall of the conch varies from 1 mm. at its base to 2 mm. at its top. At the lower end of the specimen nearly 4 camerae occur in a length equal to the dorso-ventral diameter of the siphuncle. At its top 3.3 camerae occur in a corresponding length. The length of the septal necks varies from a little over 1 mm. at the base of the specimen to fully 1.5 mm. at its top. That segment of the siphuncle which projects beneath the septum at the base of the specimen apparently corresponds to the lowest segment preserved in *Actinoceras paquettense*. It differs from the latter, however, in not being conspicuously smaller in diameter than the immediately overlying segment, and neither the first nor the second segment in this case is conspicuously taller than the overlying segments. However, this basal segment rises distinctly in a dorsal direction, and its lower surface is indented by a relatively large opening connecting with the endosiphon.

Occurrence.—Caney fork, DeKalb county, Tennessee; either from the Cannon or possibly the basal Tyrone. Holotype; specimen no. 82194; U. S. National Museum.

Remarks.—This species is characterized by the separation of the siphuncle from the ventral wall of the conch by an interval of 1 to 2 m.; the siphuncle does not diminish in diameter toward the top, at least not in the length preserved; and the lowest segment of the siphuncle preserved is similar in height and diameter to the overlying ones.

The considerable variation in the length of the septal necks of the type specimen is very remarkable. There are very short septal necks, as in the seventh and eighth segment from the base of the specimen, and also very long ones, as in the thirteenth and fourteenth segments, the latter being almost twice as long as the former. This means that the length of the septal necks is not always necessarily a distinct specific feature.

### 8. **Actinoceras capitolinum** (Safford)

*Plate XLI, figs. 1A, B, C; plate LVII, fig. 7*

*Orthoceras capitolinum* Safford, Geology of Tennessee, 1869, p. 290, pl. 4, figs. 1a, b (not fig. 1c).

Specimen 160 mm. long. At its top the ventral side of the conch is preserved for a length of 45 mm., and for almost its entire width. This width is estimated here at 51 mm. The conch enlarged apparently at a slow rate, but its apical angle can not be determined even approximately. The ventral side of the conch is strongly flattened, but its ventrolateral parts are much more strongly rounded, suggesting an approximately semicircular dorsal outline for the cross-section. Ten camerae occupy a length of 42 mm., indicating 12 camerae in a length equal to the lateral diameter of the conch at the top of the specimen. The sutures of the septa curve downward ventrally fully 9 mm. beneath their level along the median part of the lateral sides of the conch. The siphuncle is in contact with the ventral wall of the conch, the area of contact being distinctly broader and taller along the lower part of the specimen than above its middle. The lowest connecting ring has a diameter of 17 mm., and other connecting rings having the same diameter occur at other levels, including the segments immediately below that part of the speci-

men retaining the ventral half of the conch; however, several of the intermediate rings attain a diameter of 18.5 or 19 mm. The lowest five connecting rings occupy a length of 33 mm.; the next five, of 32 mm.; the next five, of 30 mm.; the next five, of 25 mm.; and the following five, of 20.5 mm. This shortening of the length of the segments of the siphuncle is not accompanied by any corresponding narrowing of their width, and probably is due to approaching gerontic conditions of the shell.

Occurrence.—Nashville, Tennessee; in the Bigby member of the Trenton. Holotype; no. 48426, U. S. National Museum.

Remarks.—Foord, in his Catalogue of Fossil Cephalopoda in the British Museum, pt. I, published in 1888, called attention to the fact that in his description of plate 4, Safford referred only figures 1A, and 1B to his *Orthoceras capitolinum* and made no mention of his figure 1C. The only reference by Safford to this species in the text of his Geology of Tennessee is on page 290, where he states that it is "Intermediate in character between Bigsbyi and anceps," and that it occurs in the Middle member of the Nashville series. Interpreting this Middle member as including among others the Capitol limestone, and as corresponding to the Bigby of present nomenclature, the type of *Orthoceras capitolinum* apparently was found in the Bigby member of the Trenton, which here is a granular, often saccharoidal and more or less whitish limestone.

Safford's types of this species have been lost, but the specimens here identified as *Orthoceras capitolinum* are at least from the Bigby, occur in a whitish saccharoidal limestone, and, as far as preserved, present an appearance quite similar to Safford's figures 1A and 1B, except in one respect; the conch, namely, does not enlarge as rapidly in a lateral direction.

On the other hand, his figure 1C represents a type of siphuncle occurring in a species here described as *Saffordoceras nelsoni*. The latter occurs in a very fine-grained limestone apparently of Catheys age. Possibly it is this difference of horizon that caused Safford to list only his figures 1A and 1B as belonging to the species *Orthoceras capitolinum*, and not to include his figure 1C which represented a specimen of distinctly higher horizon.

*Conotubularia cuvierii* Troost.[22]—The specimen described and figured by Troost under this name was stated by him to have been obtained in the lower 50 feet of the section exposed along the Cumberland River at Nashville, Tennessee. This lower part includes both Hermitage and Bigby, and it is assumed that Troost's specimen was obtained in the Bigby. However, Troost's species *Conotubularia cuvierii* differs from Safford's species *Orthoceras capitolinum* in the following particulars. The conch enlarges laterally at an apical angle of 12 degrees. The lateral diameter of the siphuncle diminishes from 20 mm. at its base to 16 mm. at its top. Successive groups of segments, each consisting of 5 segments, present the following lengths, beginning at the base of the specimen: 29.5 mm., 27 mm., 24 mm., and again about 24 mm. The lower connecting rings present distinctly broader outlines, and hence appear lower compared with their width. The greater rate of enlargement of its conch is a feature not possessed by any specimen at hand.

### 9. **Actinoceras centrale** Foerste

*Plate XXXVI, fig. 1; plate LVI, fig. 6*

*Actinoceras tenuifilum centrale* Foerste, Denison Univ. Bull., vol. 19, 1921, p. 293, pl. 28, fig. 1; pl.32, fig. 4.

Specimen 140 mm. long, enlarging from a lateral diameter of 36 mm. at its base to 57 mm. at a point 120 mm. farther up. Seven camerae occur in a length equal to the lateral diameter at the top of the specimen, decreasing to 6.5 camerae near its base. The concavity of the septa at the top equals 10 mm. The center of the siphuncle here is estimated to have been 32 mm. from the dorsal wall of the conch, the lateral diameter of the conch being 59 mm. Since the dorsoventral diameter of this specimen is not known at any point it is not possible to determine with certainty the degree of excentricity of the siphuncle, but it is believed to be small. The siphuncle has been cut nearly vertically in a lateral direction, exposing a considerable part of the endosiphuncle. In its present condition the lateral diameter of the siphuncle varies

[22] Troost, Gerard, Mem. Soc. Geol. France, vol. 3, 1838, p. 88, pl. 9, fig. 1.

from 22 mm. at its base to 26 mm. at the seventh segment from the base, the latter diameter being retained as far as the top of the specimen. The number of segments in a length equal to the diameter of the siphuncle varies from 4 at its base to 3.7 along its mid-length, and to 3.3 segments at its top. The septal necks are 18 mm. in diameter and 1.5 mm. in length where the height of the camerae is 12 mm. The lower face of the connecting rings is in contact with the inner part of the septa beneath for a width of 2 to almost 3 mm. At the base of the specimen the siphuncle protrudes downward for a width of 16 mm. and a length of a little over 2 mm., this part being broadly indented here for a depth of 2.5 mm. by the opening which connects with the endosiphuncle.

Occurrence.—Watertown, New York, in the Watertown member of the Black River. Holotype; U. S. National Museum; no. 78483.

Another specimen from the same locality, but only 75 mm. long, shows the nearly central location of the siphuncle better. U. S. National Museum; no. 82209.

Remarks.—*Actinoceras centrale* differs from typical *Actinoceras tenuifilum* in the shortness of its septal necks. No other species of *Actinoceras* so far known has a siphuncle as central as that of the species here described.

### 10. **Actinoceras cinctum** Sp. nov.

*Plate L, figs. 3A, B*

Specimen 48 mm. long, consisting only of a weathered siphuncle, which is characterized chiefly by its abrupt constriction at the septal neck, along the lower face of the overlying connecting ring as well as along the upper side of the underlying ring. This lower face of the overlying ring curves much more directly inward than in *Actinoceras adnatum*, that of the latter species slanting more obliquely downward and inward. The diameter of this siphuncle increases from 17.2 mm. at its lowest segment to 19.5 mm. at the second one, and to 20 mm. at the overlying segments. The number of these segments in a length equal to the diameter of the siphuncle is almost 3. The segments are at right angles to the

length of the siphuncle. Where the connecting rings are 5 mm. long, the length of the septal necks is about 1.5 mm.

Occurrence.—Glencoe, Missouri; in the upper part of the Plattin or Lowville division of the Black River. Holotype; specimen no. 82195; U. S. National Museum.

### 11. **Actinoceras circulare** Sp. nov.

*Plate XL, figs. 1A, B; plate LVI, fig. 8*

Specimen 75 mm. long, enlarging at an angle of 10 degrees. Approximately circular in cross-section. About 30 mm. below its top the diameter is estimated at 36 mm., that of the siphuncle being 27 mm. This siphuncle is about 9 mm. from the dorsal wall of the conch, but ventrally it appears to be in contact with the wall, as far as can be determined from a reconstruction of the conch. Four septa occupy a length of 35 mm. The sutures of the septa appear to curve distinctly downward ventrally. The diameter of the siphuncle enlarges from 25 mm. at its base to 29 mm. at its top. The ratio of the diameter of the siphuncle to that of the conch equals 75 per cent. The deposits within the siphuncle show both radial and minutely vesicular structure.

Occurrence.—Glencoe, Missouri; in the upper part of the Plattin member of the Black River, approximately equivalent to the Lowville. Holotype; U. S. National Museum; no. 82208.

This species is closely similar to *Actinoceras saffordi, Actinoceras tennesseense,* and *Actinoceras jessaminense,* but differs chiefly in its more circular cross-section.

### 12. **Actinoceras curdsvillense** Sp. nov.

*Plate XXXIX, figs. 2A, B; plate LVI, fig. 9*

Specimen 52 mm. long, preserving the ventral side of the conch. Its lateral diameter is estimated at 46 mm. Its cross-section appears to have been approximately circular, but its dorsoventral diameter may have been shorter than its lateral one. Eight camerae occur in a length of 42 mm., which corresponds to 10 camerae in a length equal to the diameter of the conch. The sutures of the septa curve downward ventrally about 6 mm.

below their highest elevation ventrolaterally, and probably not more than 8 mm. below their course dorsally, the dorsal side of the conch not being preserved. The siphuncle appears to touch the ventral wall of the conch at the top of the specimen, but there is no evidence of flattening of the contact area of the connecting ring here. It is possible that at the lower end of the specimen the contact resulted in some slight degree of flattening, but this is uncertain. The length of the septal necks varies from 1.5 mm. at the base of the specimen to 1 mm. at its top.

Occurrence.—Curdsville, Kentucky; in the Curdsville member of the Trenton. Holotype; specimen no. 48425, U. S. National Musuem.

Remarks.—This species is characterized chiefly by the relative shortness of its camerae, its approximately circular cross-section, and the slight contact between the siphuncle and the ventral wall of the conch.

In the extreme shortness of its septal necks this species resembles somewhat *Actinoceras* (?) *lindenense*, although the latter enlarges at a smaller rate, and the diameter of its siphuncle is considerably smaller when measured at a diameter of the conch comparable with that of *Actinoceras curdsvillense*. The conch of *Actinoceras curdsvillense* apparently was relatively short, compared with most other species of the genus.

### 13. **Actinoceras glencoense** Sp. nov.

*Plate XL, figs 2A, B, C; plate LVI, fig. 11*

Specimen 78 mm. long, enlarging at an angle of 11 degrees laterally. The lowest camera preserved has a lateral diameter of 29 mm. Three segments of the siphuncle are preserved below the level of this camera, occupying a length of 25 mm. Where the lateral diameter of the conch is 33 mm., the dorsoventral one is estimated at 30 mm., the ventral side being distinctly flattened. Along the greater part of the length of the specimen 5.5 camerae occur in a length equal to the lateral diameter of the conch, but the lower two segments of the siphuncle are distinctly longer than the immediately overlying camerae, and both slope more distinctly downward in a ventrad direction, especially in case of the

lowest segment preserved. The sutures of the septa curve downward ventrally at least 3 mm. below their level laterally. The siphuncle is in contact with the ventral wall of the conch, the connecting rings presenting contact areas which vary in width from 20 mm. at the third segment above the base of the specimen to 9 mm. at the eighth. The lowest segment has a lateral diameter of 18.5 mm.; the overlying segments apparently presenting an almost constant diameter of 21 mm. The lowest segment evidently corresponds to the lowest segment preserved in such species as *Actinoceras paquettense*, but it is only slightly smaller in diameter and only slightly taller than the third and overlying segments. Its lower surface is broadly and deeply indented by the basal opening of the endosiphon.

A second specimen differs only in attaining a greater length; namely, 92 mm.

Occurrence.—Glencoe, Missouri; in the upper part of the Plattin or Lowville division of the Black River. The specimen described first is the holotype; no. 82197A; U. S. National Museum. The second is numbered 82197B.

### 14. **Actinoceras glenni** Sp. nov.

*Plate XXXI, figs. 1A, B, C; plate LVI, fig. 10*

Specimen differing from *Actinoceras tenuifilum* chiefly in the greater length of its camerae along the lower part of the specimen, and in the lack of conspicuous change in their length farther up. Moreover, the septal necks are longer, even at the lower end of the specimen.

Specimen 140 mm. long, enlarging from a lateral diameter of 30.5 mm. at the lowest camera preserved to 42 mm. at a point 58 mm. farther up. Where its lateral diameter is 39 mm., its dorsoventral one is 35 mm. The ventral part of its cross-section is slightly flattened. The lowest 4 camerae preserved occupy a total length of 39 mm., and this is true also of the overlying groups of 4, there being no change in the length of the camerae within the length preserved. The sutures of the septa are directly transverse dorsally, but curve downward ventrally at least 7 mm. where the lateral diameter of the conch is 39 mm. The concavity

of the septa equals about the height of one camera. The diameter of the siphuncle increases from 20 mm. at the segment exposed at its base to 28 mm. at the tenth segment from this end, diminishing thence to 23 mm. at the thirteenth segment. Along the lower end of the specimen these segments are in contact with the ventral wall of the conch along lenticular areas 7 mm. in height. Where the siphuncle diminishes in diameter it probably becomes free from contact with this ventral wall. Where the height of the camerae is 10 mm., the septal necks occupy a length of 3 mm. At the base of the specimen that segment of the siphuncle which protrudes beneath that part of the conch retaining its camerae is similar in form to the overlying segments.

Occurrence.—Nashville, Tennessee; possibly in the Tyrone member of the Lowville. Collected by L. C. Glenn. Holotype; U. S. National Museum; no. 82207.

A specimen closely similar to the basal part of the type of *Actinoceras glenni*, but only 40 mm. long, was found on Caney creek, in De Kalb county, Tennessee; possibly in the Tyrone; U. S. National Museum; no. 82206.

Remarks.—*Actinoceras glenni* is characterized by the strong and sharp downward curvature of the sutures of its septa on the ventral side of the conch. In this respect it resembles typical *Actinoceras bigsbyi*, but in the latter the ventral lobes of the sutures are broader than in *Actinoceras glenni*. This species is named in honor of L. C. Glenn, long connected with geological investigations in Tennessee.

### 15. **Actinoceras jessaminense** Sp. nov.

*Plate XXXVIII, figs. 1A, B; plate LVII, fig. 2*

Specimen 75 mm. long, enlarging both laterally and dorsoventrally at an angle of 9.5 degrees. At its top its dorsoventral diameter is 38 mm. Where this diameter is 34 mm., the lateral one is estimated at 37 mm. The cross-section of the conch is elliptical, the transverse curvatures dorsally and ventrally being similar. About 5.5 camerae occur in a length equal to the lateral diameter of the conch. The sutures of the septa curve strongly downward ventrally. At the base of the specimen the siphuncle

appears to have been in contact with the ventral wall of the conch, but at its top it may have been free from the latter, possibly as much as 2 or 3 mm. At the base of the specimen the dorsoventral diameter of the siphuncle is estimated at 23 mm., shortening to 19 mm. at its top.

Occurrence.—High Bridge, Kentucky; in the Tyrone member of the Lowville. Holotype; specimen no. 82198; U. S. National Museum.

### 16. **Actinoceras kentuckiense** Sp. nov.

*Plate XXXII, figs. 1A, B; plate XXXIII, fig. 1; plate LVII, fig. 3*

Specimen 150 mm. long, enlarging at an apical angle of 13.5 degrees laterally and 10 degrees dorso-ventrally. At its base its lateral diameter is 29 mm.; at a point 75 mm. farther up, where its lateral diameter is 45 mm., its dorsoventral one is 40 mm. The number of camerae in a length equal to the lateral diameter varies from 4 at the lower end of the specimen to 5 near its top. The sutures of the septa curve downward ventrally from the dorsal toward the ventral side of the conch. Where the lateral diameter is 44 mm., the sutures rise 4 mm. dorsally and curve downward ventrally 9 mm. from their level along the median line of the lateral side of the conch. The siphuncle is in contact with the ventral side of the conch. Along its lower end the connecting rings may have been flattened along the line of contact, but farther up there is no evidence of such flattening.

Occurrence.—High Bridge, Kentucky; in the Tyrone member of the Lowville. Holotype; specimen no. 82237; U. S. National Museum.

Remarks.—*Actinoceras kentuckiense* is characterized chiefly by the great length of its septal necks. The length of these septal necks equals about two-fifths of that of the camerae, so that these necks are even longer than those of *Actinoceras bigsbyi*. This extreme length of the septal necks can be observed already at the earlier stages of growth. Moreover, the distance between the septa varies relatively little between earlier and later stages of growth.

### 17. **Actinoceras lentiexpandum** Sp. nov.

*Plate XXXVI, fig. 2; plate LVII, fig. 1*

Specimen 140 mm. long, enlarging from a lateral diameter of 33 mm. a short distance above its base to 56 mm. at its top, which is is 110 mm. farther up. Where the lateral diameter is 45 mm., the dorsoventral one is estimated at 41 mm. The ventral side of the cross-section is less strongly curved than the dorsal one. The number of camerae in a length equal to the lateral diameter of the conch varies from 5 along its lower third, to 6.5 along its middle, and to 7.5 mm. along its upper third. The sutures of the septa are directly transverse dorsally but curve downward 7 or 8 mm. ventrally. The dorsoventral diameter of the siphuncle enlarges from 32 mm. at its base to 26 mm. at the twelfth segment above the base, retaining this diameter of 26 mm. as far as the eighteenth segment, which forms the top of the specimen. The lower segments of the siphuncle are in contact with the ventral wall of the conch, but at the seventh or eighth segment the siphuncle becomes free and slowly recedes from this wall, becoming 1.5 mm. distant at the top of the specimen. In a dorsoventral section of the conch the septa appear straight, rising at an angle of about 12 to 15 degrees in a dorsad direction.

Compared with *Actinoceras libanum*, the siphuncle attains a larger diameter, its camerae are more numerous along the upper part of the specimen, its septal necks are shorter, and their contact with the connecting rings beneath is more angular.

Occurrence.—From some unknown locality in Central Tennessee; from the lower part of the Cannon limestone. Holotype; U. S. National Museum; no. 82211.

### 18. **Actinoceras libanum** Sp. nov.

*Plate XXXIV, figs. 1A, B, 2; plate LVII, fig. 5*

Specimen 140 mm. long, enlarging laterally from a diameter of 30 mm. at the lowest camera preserved to 42 mm. at a point 75 mm. farther up. Where the lateral diameter is 40 mm. the dorsoventral one equals 34 mm. The cross-section of the conch is transversely elliptical, the ventral side being only slightly less

curved than the dorsal one. About 5 camerae occur in a length equal to the lateral diameter of the conch. The sutures of the septa are almost directly transverse dorsally, but curve conspicuously downward ventrally, to an extent of about 7 mm. at the top of the specimen. The dorsoventral diameter of the siphuncle enlarges from 18 mm. at the base of the specimen to 24.5 mm. at the eighth segment above the base, diminishes to 22 mm. at the eleventh segment, and retains this diameter at least as far as the fourteenth segment, which is the highest segment whose diameter can be measured. The lower 7 or 8 segments are in contact with the ventral wall of the conch, but above this level there is a slight separation equal to about 1 mm. The length of the septal necks and of the connecting rings increases in about the same ratio as the diameter of the conch. Along the upper end of the specimen these necks are 2 mm. long, but form an angulate junction with the connecting rings beneath. In a dorsoventral section of the conch the septa appear straight, rising at an angle of 12 to 15 degrees above the horizontal in a dorsad direction.

A second specimen from the same locality is 165 mm. long. A single segment of the siphuncle protrudes beneath the lowest camera preserved. The lateral diameter of the conch enlarges from 28 mm. at the base of the specimen to 46 mm. at a point 95 mm. farther up. The dorsoventral diameter is 26 mm. at the base of the specimen. Farther up, the specimen was more strongly depressed, but no exact measurement can be made.

Occurrence.—High Bridge, Kentucky; in the Lebanon division of the Camp Nelson formation. Cotypes; U. S. National Museum; no. 48424A, B.

### 19. **Actinoceras** (?) **lindenense** Sp. nov.

*Plate XXXIII, fig. 2*

Specimen 140 mm. long, enlarging at an apical angle of 6.5 degrees. The apical end of the specimen begins with a blunt downward projection, as in various other specimes of *Actinoceras*. At 8 mm. above this end the lateral diameter of the conch is 18 mm. Where this diameter equals 25 mm. the underlying 5 camerae occupy a corresponding length, increasing to 5.5 camerae

in a length equal to the diameter of the conch where the latter is estimated at 36 mm. At 20 mm. above the apical end of the specimen the cross-section of the ventral half of the conch is semicircular, with no trace of ventral flattening. The siphuncle here is close to the ventral wall of the conch, but apparently is free from actual contact. The lower 9 segments of the siphuncle vary between 14 and 15 mm. in diameter, diminishing thence gradually to 10 mm. at the seventeenth segment above its base. Above this point the diminution in the diameter of the conch apparently continues but at a slower rate; however, no exact measurements are possible. Traces of the siphuncle continue as far up as the twenty-fifth camera. Along the lower part of the specimen the segments of the siphuncle appear like low broad disks, while at the seventeenth segment the vertical outline is more nearly circular. At both levels the length of the septal necks varies between 1 and 1.2 mm. Along the upper part of the specimen the curvature of the septa is relatively small.

Occurrence.—Linden Hall, Center county, Pennsylvania; in the Lowville limestone. Holotype; specimen no. 82229, U. S. National Museum.

Remarks.—The narrowing of the siphuncle at later stages of growth has been observed in other orthoconic actinoceroids. In *Paractinoceras canadense* (Whiteaves),[23] from the Dog Head member of the Red River formation, on Swampy island, in Lake Winnipeg, Manitoba, there is a similar diminution in the diameter of the siphuncle, but the camerae are relatively taller, the lower segments of the siphuncle are relatively taller, and the septal necks are longer. More striking differences consist in the dorso-ventral depression of the conch, and in the strong downward curvature of the sutures of the septa ventrally. In the species described by Barrande under the name *Orthoceras docens*,[24] from the Gotlandian division of the Silurian (E) at Dvoretz, in

[23] Foerste, Aug. F., The cephalopods of the Red River formation of Southern Manitoba, Jour. Sci. Lab., Denison Univ., vol. 24, 1929, p. 210, pl. 14, fig. 2; pl. 26, figs. 3A, B.

[24] Barrande, Joachim, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, 1874, p. 632; pl. 250, figs. 1–10, published in 1868.

Czechoslovakia (formerly Bohemia), there is a similar contraction of the upper part of the siphuncle, but the structure of the siphuncle indicates its relationship to the recently proposed genus *Armenoceras,* the septal necks being very short. Moreover the location of this siphuncle is central.

### 20. **Actinoceras paquettense** Sp. nov.

*Plate XXXVIII, figs. 3A, B, C; plate LVII, fig. 6*

Specimen 74 mm. long, retaining the lower part of the siphuncle and part of the ventral side of the conch. This ventral side is strongly flattened, compared with the remainder of the cross-section of the conch, as shown by other specimens. The sutures of the septa curve downward ventrally. Their downward curvature at the base of the specimen, as shown in other specimens is relatively strong. The siphuncle is in broad contact with the ventral wall of the conch, presenting broad contact areas along the connecting rings. The lower end of the specimen is broadly rounded. The first two segments of the siphuncle are conspicuously taller than the rest, their height being respectively 9 and 10 mm. The third segment is 7 mm. in height, and from this level the height of the segments diminishes to 6 mm. at the top of the specimen. The dorso-ventral diameter of the first three segments is 21, 26, and 26 mm. respectively, diminishing gradually to 23 mm. at the sixth segment. The corresponding lateral diameters are 23, 30, and 30 mm., diminishing gradually to 24 mm. at the seventh segment, and to 18 mm. at the tenth.

The bluntly and broadly rounded apical end of the specimens in their present state of preservation is not the original initial end of the conch. This is shown very well by one of the specimens in which the margin of the septum at the base of the lowest segment of the siphuncle preserved is distinctly outlined along the base of the wall of the conch, the septum meeting the wall of the conch at a distinct angle, below which evidently once was attached the real initial end of the conch, no trace of which is preserved in any specimen at hand.

Occurrence.—Paquette rapids, about 70 miles northwest of Ottawa, on the Ottawa river in Canada; in the Leray member of

Lowville. Cotypes, no. 6294, in the collection of the Victoria Memorial Museum.

Remarks.—*Actinoceras paquettense* is characterized chiefly by its large, round, blunt apical end, in the present condition of preservation of all of the specimens found, and in the relatively rapid contraction of the siphuncle, both dorsoventrally and laterally, above its third or fourth segment.

This apparently is the shortest species of *Actinoceras* known. That the original length of the conch did not exceed to any considerable extent the length of the figured specimen is indicated by the constriction of the siphuncle in diameter toward its top, this constriction always indicating that the conch had attained its gerontic stage of growth. Although the length of the living chamber is not known, it may be assumed not to have equalled that of the phragmacone.

There are some strong resemblances between *Actinoceras paquettense* and the various species referred to the genus *Kochoceras*, especially in the strong flattening of the ventral side of its conch. Although the entire length of its conch is not known, that part which is preserved suggests that the siphuncle occupied the greater part of the interior of the conch, as in that genus. One striking difference, however, consists in its small size, that of typical *Kochoceras* being considerably larger. A more important difference is presented by the smaller apical end of *Actinoceras paquettense*, that of typical *Kochoceras* being considerably larger in size.

### 21. **Actinoceras pohli** Sp. nov.

*Plate XXXVII, figs. 2A, B, C; plate LVII, fig. 8*

Specimen about 50 mm. long, enlarging at an angle of 6.5 degrees dorsoventrally, its lateral angle being unknown. Enough of the cross-section remains to indicate that the maximum lateral diameter was ventrad of the center of the conch, the ventral side being distinctly flattened. At the top of the specimen its dorsoventral diameter is 43 mm. In a corresponding length there are 5.5 camerae; however, the lower 3 camerae occupy a length of 25 mm., and the overlying 3 of only 20 mm. The sutures

of the septa curve downward at least 5 mm. ventrally, possibly more. The diameter of the siphuncle decreases from 28 mm. at the base of the specimen to 25 mm. at its top. The distance of the siphuncle from the ventral wall of the conch increases from 2 mm. at the base of the specimen to 2.5 mm. at its top. The length of the septal necks is between 1.8 mm. and 2 mm.

Occurrence.—From some unknown locality in middle Tennessee; presumably from the Carters member of the Lowville. Holotype; specimen no. 82205; U. S. National Museum.

Remarks.—This species is named in honor of Irwin Pohl, at present actively at work on the geology of Tennessee.

### 22. **Actinoceras ruedemanni** Sp. nov.

*Plate LII, fig. 2; plate LVII, fig. 9*

Specimen 190 mm. long in its present condition; not suitable for a study of its cross-section. Its dorsoventral diameter enlarges from 27 mm. at the base of the lowest camera preserved to 42 mm. at a point 95 mm. farther up. The corresponding diameters of the siphuncle at these two points are 21 mm. and 28 mm. Above the upper point mentioned the diameter of the siphuncle diminishes, at first slowly to 26 mm. at a point two segments of the siphuncle farther up, and then to an estimated diameter of 18 mm. at the uppermost segment exposed, the latter being 5 segments above the one last mentioned. At the lower end of the specimen the segments of the siphuncle are in contact with the ventral wall of the conch for at least the lower 8 or 9 camerae. Above this point they gradually become more distant from this wall, until at the uppermost segment this distance fully equals 3 mm. Even at the lower end of the specimen there is no flattening of the ventral side of the connecting rings, but only mere contact along the outer rim of the latter. On this ventral side of the siphuncle the septa can be distinguished only where the connecting rings are free from contact with the ventral wall of the conch. On the dorsal side of the siphuncle the septa present straight outlines in a dorsoventral section through the conch, rising at an angle of 15 degrees above the horizontal. Along that part of the conch in which the dorsoventral diameter of the siphuncle in-

creases, the length of the segments of the siphuncle increases in the same ratio, the number of segments in a length equal to this diameter remaining constantly about 3. Above this point, where the siphuncle begins to contract, the increase in the length of the segments of the siphuncle continues at the same rate as farther down. At the same time the length of the septal necks increases from 1 mm. at the lower end of the specimen to 2 or 3 mm. at its top, changing its form gradually from more or less narrowly and angularly rounded to more broadly rounded, especially along the dorsal side of the siphuncle. No. 82215; U. S. National Museum; holotype.

In other specimens from the same locality, the segments of the siphuncle are in contact with the ventral wall of the conch along flattened areas which are 3 or 4 mm. in height at the lower end of the specimen, but become free at the eleventh or twelfth segment above the base. Nos. 4774, 5006 A; U. S. National Museum.

Specimens preserving the dorsal as well as the ventral side of the conch are relatively rare, and these alone are suitable for cross-sections. In one of these the dorsoventral diameter of the conch is 53 mm. where the lateral one is 65 mm., and the ventral side of the cross-section has a radius of transverse curvature of 50 mm. while that of the dorsal side is nearer 40 mm., showing that the conch was slightly depressed dorsoventrally, and that its ventral side was slightly flattened. No. 34019B; U. S. National Museum.

Occurrence.—Watertown, New York; in the Watertown member of the Black River. Species named in honor of Dr. Rudolf Ruedemann, State Paleontologist of New York, in recognition of his important contributions to our knowledge of the cephalopods of New York, and Vermont.

Remarks.—This species appears to be more common in the Watertown limestone of New York than typical *Actinoceras tenuifilum*. Apparently the specimen represented by fig. 1b on plate 16, in the Paleontology of New York, vol. 1, under the name *Ormoceras tenuifilum* Hall, belongs to this species. Another figured specimen is that represented by fig. 2 on plate 28 of the Jour. Sci. Lab., Denison Univ., vol. 19, 1921, from Watertown,

of the septa curve downward at least 5 mm. ventrally, possibly more. The diameter of the siphuncle decreases from 28 mm. at the base of the specimen to 25 mm. at its top. The distance of the siphuncle from the ventral wall of the conch increases from 2 mm. at the base of the specimen to 2.5 mm. at its top. The length of the septal necks is between 1.8 mm. and 2 mm.

Occurrence.—From some unknown locality in middle Tennessee; presumably from the Carters member of the Lowville. Holotype; specimen no. 82205; U. S. National Museum.

Remarks.—This species is named in honor of Irwin Pohl, at present actively at work on the geology of Tennessee.

22. **Actinoceras ruedemanni** Sp. nov.

*Plate LII, fig. 2; plate LVII, fig. 9*

Specimen 190 mm. long in its present condition; not suitable for a study of its cross-section. Its dorsoventral diameter enlarges from 27 mm. at the base of the lowest camera preserved to 42 mm. at a point 95 mm. farther up. The corresponding diameters of the siphuncle at these two points are 21 mm. and 28 mm. Above the upper point mentioned the diameter of the siphuncle diminishes, at first slowly to 26 mm. at a point two segments of the siphuncle farther up, and then to an estimated diameter of 18 mm. at the uppermost segment exposed, the latter being 5 segments above the one last mentioned. At the lower end of the specimen the segments of the siphuncle are in contact with the ventral wall of the conch for at least the lower 8 or 9 camerae. Above this point they gradually become more distant from this wall, until at the uppermost segment this distance fully equals 3 mm. Even at the lower end of the specimen there is no flattening of the ventral side of the connecting rings, but only mere contact along the outer rim of the latter. On this ventral side of the siphuncle the septa can be distinguished only where the connecting rings are free from contact with the ventral wall of the conch. On the dorsal side of the siphuncle the septa present straight outlines in a dorsoventral section through the conch, rising at an angle of 15 degrees above the horizontal. Along that part of the conch in which the dorsoventral diameter of the siphuncle in-

creases, the length of the segments of the siphuncle increases in the same ratio, the number of segments in a length equal to this diameter remaining constantly about 3. Above this point, where the siphuncle begins to contract, the increase in the length of the segments of the siphuncle continues at the same rate as farther down. At the same time the length of the septal necks increases from 1 mm. at the lower end of the specimen to 2 or 3 mm. at its top, changing its form gradually from more or less narrowly and angularly rounded to more broadly rounded, especially along the dorsal side of the siphuncle. No. 82215; U. S. National Museum; holotype.

In other specimens from the same locality, the segments of the siphuncle are in contact with the ventral wall of the conch along flattened areas which are 3 or 4 mm. in height at the lower end of the specimen, but become free at the eleventh or twelfth segment above the base. Nos. 4774, 5006 A; U. S. National Museum.

Specimens preserving the dorsal as well as the ventral side of the conch are relatively rare, and these alone are suitable for cross-sections. In one of these the dorsoventral diameter of the conch is 53 mm. where the lateral one is 65 mm., and the ventral side of the cross-section has a radius of transverse curvature of 50 mm. while that of the dorsal side is nearer 40 mm., showing that the conch was slightly depressed dorsoventrally, and that its ventral side was slightly flattened. No. 34019B; U. S. National Museum.

Occurrence.—Watertown, New York; in the Watertown member of the Black River. Species named in honor of Dr. Rudolf Ruedemann, State Paleontologist of New York, in recognition of his important contributions to our knowledge of the cephalopods of New York, and Vermont.

Remarks.—This species appears to be more common in the Watertown limestone of New York than typical *Actinoceras tenuifilum*. Apparently the specimen represented by fig. 1b on plate 16, in the Paleontology of New York, vol. 1, under the name *Ormoceras tenuifilum* Hall, belongs to this species. Another figured specimen is that represented by fig. 2 on plate 28 of the Jour. Sci. Lab., Denison Univ., vol. 19, 1921, from Watertown,

New York, under the name *Actinoceras tenuifilum* (Hall). It may have been *Actinoceras ruedemanni*, rather than typical *Actinoceras tenuifilum*, which Clarke had in mind when he compared the Minnesota specimens referred by him to *Actinoceras bigsbyi* with the *Ormoceras tenuifilum* of Hall.

### 23. **Actinoceras saffordi** Sp. nov.

*Plate XXVII, figs. 2 A, B; plate LVII, fig. 4*

Specimen about 47 mm. long, enlarging at an apical angle of 13 degrees laterally, and approximately at 11 degrees dorsoventrally. The cross-section of the conch is elliptical, the transverse curvature of the dorsal and ventral outlines being similar. At the top of the specimen, where its lateral diameter is 45 mm., the dorsoventral one is approximately 40 mm. The number of camerae in a length of 40 mm. is 5. The sutures of the septa curve downward ventrally about 8 mm. The dorsoventral diameter of the siphuncle varies from 23.5 at the base of the specimen to 26.5 mm. at its top. The connecting rings are in contact with the ventral wall of the conch for a height of 3 mm. The length of the septal necks is nearly 2 mm.

Occurrence.—Motley's, Tennessee, the exact location of this locality not being known. Presumably from the Carters member of the Lowville. Holotype; specimen no. 82199; U. S. National Museum. Another specimen, from Hermitage station, Tennessee, is from the top of the Carters member, and is numbered 82200, in the same museum.

Remarks.—This species is named in honor of J. M. Safford, for 50 years intimately connected with geological investigations in Tennessee, and for most of that time in service as State Geologist.

### 24. **Actinoceras** cf. **saffordi** Sp. nov.

*Plate XXX, fig. 2*

Specimen 65 mm. long, its lateral diameter being estimated at 40 mm. Its cross-section and rate of enlargement are unknown. About 4.5 camerae occur in a length of 40 mm. The sutures of the septa curve downward ventrally. The lateral diameter of

the siphuncle is 28 mm. The dorso-ventral diameter varies from 25 mm. at the lowest connecting ring preserved to 26.5 mm. at the third and fourth. The connecting rings are in contact with the ventral wall of the conch, the lowest contact area being 6 mm. high and 25 mm. broad, and the uppermost one preserved is almost 5 mm. tall and about 15 mm. broad. The length of the septal necks is about 1.75 mm.

Occurrence.—East of Franklin, Tennessee; in the top of the Carter's member of the Lowville. Specimen no. 82201; U. S. National Museum.

Remarks.—In the size of the conch and of the siphuncle this specimen is similar to *Actinoceras saffordi*. Its cross-section appears to be more circular and the contact areas of the siphuncle appear to be broader laterally. However, since the exact cross-section of this Franklin specimen is unknown, and the exact lateral width of the contact areas in the Motley specimen also is uncertain, accurate comparison with the type of *Actinoceras saffordi* is impossible.

### 25. **Actinoceras tennesseense** Sp. nov.

*Plate XXXV, figs. 2A, B; plate LIX, fig. 8*

Specimen 43 mm. long, enlarging at an apical angle of 12.5 degrees laterally, and at almost the same angle dorsoventrally. At the top of the specimen the lateral diameter is 39 mm. and the dorsoventral one is 36 mm., its cross-section being nearly circular. Five camerae occupy a length of 39 mm. The sutures of the septa curve downward ventrally for a distance of about 7 mm. below their level dorsally. Dorsally their downward curvature in a ventrad direction is slight. The diameter of the siphuncle varies from 23 mm. at the base of the specimen to 27 mm. at its top. Its cross-section appears circular. However, at the base of the specimen the area of contact between the connecting ring and the ventral wall of the conch is 3 mm. in height, while at its top there appears to be mere contact without any flattened area. The septal necks are about 1.5 mm. in length.

Occurrence.—Labelled as coming from Motley's, Tennessee, the exact location of this locality being unknown. Apparently

from the Carter's member of the Lowville. Holotype; specimen no. 82202; U. S. National Museum.

### 26. **Actinoceras tenuifilum** (Hall)

*Plate XXVIII, fig. 1; plate XXXIX, fig. 4; plate LVII, fig. 10*

*Ormoceras tenuifilum* Hall, New York, 1. p. 55, pl. 15, figs. 1, 1a, 1b, 1847.

*Actinoceras tenuifilum* Foerste, Denison Univ. Bull., 19, p. 284, 1921.

Type.—Specimen 205 mm. long, enlarging laterally from a diameter of 34 mm. at its base to 75 mm. at a point 195 mm. farther up, its apical angle in that direction being 12 degrees. Where the lateral diameter of the conch is 43 mm., the dorsoventral one is 41 mm.; where its lateral diameter is 48 mm., the dorsoventral one is 42.5 mm.; and where its lateral diameter is 61 mm., the dorsoventral one is estimated at 52 mm. The corresponding ratios between these two diameters at the three points mentioned are 0.953, 0.885, and 0.854, indicating that the dorsoventral depression of the conch was slight along its lower part, but increased toward its top, its ventral side being slightly more depressed than its dorsal one. From the lower end of the specimen up to a point where its lateral diameter is 45 mm. the number of camerae in a length equal to the lateral diameter of the conch is six, increasing to seven along the upper part of the specimen. The lowest 6 camerae occupy a length of 42 mm. The upper 10 camerae occupy a length of 104 mm. Of the latter group the lower camerae are approximately 8 mm. long, increasing to 11 or 12 mm. toward the top of this group. The concavity of the septa is moderate, that of the septum at the top of the specimen being approximately 10 mm. The lateral diameter of the siphuncle is about 22.5 mm. at the base of the specimen, increasing to 26 mm. at a point 42 mm. farther up, and to 27 mm. above an additional interval of 21.5 mm. Above a third interval of 73 mm. its diameter is still 26 mm., showing a nearly constant diameter for a length of almost 100 mm. The diameter of the septal foramen at the four points mentioned is 15 mm., 19 mm., 20 mm., and again about 19 mm.; but nothing certain is known about its

diameter at the top of the specimen, which is 55 mm. above the point last mentioned, although the diameter of the septal foramen here appears to be less. The siphuncle is located close to the ventral side of the conch. Along the lower part of the specimen, for a length of 45 mm., the crests of the connecting rings appear to be in actual contact with the ventral wall of the conch, with no trace of flattened contact areas. However, 30 mm. farther up the crests of these rings are 1 mm. distant from this ventral wall, and above an additional interval of 65 mm. they are fully 4 mm. distant. Above this point nothing definite is known about the siphuncle. Since the siphuncle enlarges very slowly along the lower 45 mm. of its length and is almost constant in diameter along the overlying 95 mm., its cross-section forms a relatively smaller part of the cross-section of the entire conch at higher levels. The structure of the siphuncle is well exposed along the lower 70 mm. of the length of the conch, chiefly along a polished transverse vertical section, but also partly along a transverse vertical break immediately above the latter. The polished vertical section was cut sufficiently diagonal to a directly transverse plane to place the left outline of the siphuncle distinctly nearer the median line of the ventral side of the conch than its right outline. The result is a slight difference in the shape and length of the septal necks as exposed on these two outlines. Where the maximum diameter of the connecting rings is 25.5 mm. and that of the septal foramen is 18 mm., the height of the camera is 6.7 mm. along the right outline of the siphuncle, 5.5 mm. of this length being occupied by the connecting ring, and 1.2 mm. by the septal neck. On the left side of the siphuncle the height of this camera is 7 mm., the length of the connecting ring being 5.1 mm., and that of the septal neck being 1.9 mm. At the septal neck the septum curves rapidly downward and then somewhat abruptly outward. The exact point at which the brim of the septal neck terminates and the underlying connecting ring begins is not clearly defined, but it appears to be about 1 mm. from the septal foramen. The lower face of the overlying connecting ring is adnate to the septum beneath for a width of 2 mm. on the right side of the siphuncle and for almost 3 mm. on its left. The shell

appears to have a thickness of 0.3 mm. at the lower end of the specimen. Its surface layer is much darker than the rest and is striated vertically. The striae are microscopic, but sharply raised, very narrow lines, averaging from 5 to 6 in a width of 1 mm., but varying from as low as 3 or 4 to as high as 7 or 8 in this width locally. Though sharply defined they are of very small height.

Occurrence.—Watertown, New York; in the Watertown member of the Black River. New York State Museum, no. 12242–1; lectotype.

Small patches of a thin, membranous, encrusting bryozoan, resembling *Ceramoporella*, are attached to the surface of the shell at several places. These are scarcely one-third of a millimeter thick, and 10 or 11 zoœcial apertures occur in a length of 5 mm., more or less arranged in intersecting rows.

Remarks.—The specific name *tenuifilum* refers to the minute threadlike vertical striae shown by the surface of the shell. Since these were known to Hall only from the specimen represented by his fig. 1 on plate 15, cited above, the latter was selected by Foerste, in 1921, as the type of the species.

## LEURORTHOCERAS Foerste

Genotype: *Leurorthoceras hanseni* Foerste, Denison Univ. Bull., vol. 19, 1921, p. 278, pl. 30, figs. 1A, B; pl. 31, fig. 1; pl. 32, fig. 8; pl. 34, fig. 2.

Conchs evidently closely related to typical *Actinoceras*, dorsoventrally depressed, with the ventral side distinctly flattened. The sutures of the septa are nearly horizontal dorsally, but curve distinctly downward ventrally. The siphuncle is located on the ventral side of the conch but is conspicuously separated from the latter in the species referred to this genus. The segments of the siphuncle are depressed globular at earlier stages of growth, but vertically elongated and more or less elliptical farther up. The septal necks are as long as in typical *Actinoceras*. Since the earlier stages of the conchs referred to *Leurorthoceras* have not been observed it is possible that in these stages the segments of the siphuncle are still broader and possibly even as broadly nummu-

loidal in form as at earlier stages of typical *Actinoceras*. In that case it is possible that along the lower part of the conch these segments might be in direct contact with the ventral wall of the conch, so that no valid reason would remain for the separation of the two genera, and the name *Leurorthoceras* in that case should be dropped. Provisionally, however, the name *Leurorthoceras* is retained for specimens similar to those originally included in this genus.

### 27. **Leurorthoceras altopontense** Sp. nov.

*Plate XLII, fig. 2*

Conch closely similar to *Leurorthoceras lebanonense*, but with no moderate downward curvature of the sutures of the septa dorsally in addition to their stronger downward curvature ventrally. In dorsoventral sections of the conch the septa appear relatively straight from the siphuncle outward, both dorsally and ventrally. They rise in a dorsad direction at an angle of 10 degrees above the horizontal. Hence they reach their lowest level on the dorsal side of the siphuncle, and not a short distance ventrad of the center of the conch.

Specimen enlarging from a lateral diameter of 46 mm. at its base to 64 mm. at a point 100 mm. farther up, near the top of the specimen. The corresponding dorsoventral diameters are estimated at 34 mm. and 48 mm. In its present condition the cross-section is transversely elliptical, with relatively strongly rounded lateral curvatures. The sutures of the septa slant slightly downward in a ventrad direction along the dorsal half of the conch, increasing to a downward curvature of 10 mm. along its ventral half. The center of the siphuncle is 11 or 12 mm. from the ventral wall of the conch. Its segments diminish in diameter from a nearly globular outline along the lower part of the specimen to much narrower forms farther up. In the third camera from the top the height of the camera is 11 or 12 mm. The diameter of the siphuncle at the septal necks is 4.5 mm., enlarging to 6.5 mm. at mid-height of the camerae. The length of the septal necks is almost 3 mm.

Occurrence.—High Bridge, Kentucky; in the Lebanon member

of the Camp Nelson formation, 130 feet above the base of its exposure, in strata about equivalent to the Lebanon limestone, the horizon at which also *Leurorthoceras lebanonense* was obtained. Holotype; U. S. National Museum; no. 82212.

### 28. **Leurorthoceras lebanonense** Sp. nov.

*Plate XLII, figs. 1A, B; plate LIX, fig. 1*

Specimen 118 mm. long, with a lateral diameter of 60 mm. and a dorsoventral one of 46 mm. at its base, the lateral diameter enlarging to approximately 75 mm. at its top. The cross-section of the conch is transversely elliptical, but with the ventral part somewhat less convex than its dorsal side. Most of the camerae are between 10 and 12 mm. in height, except at the top where the upper 3 camerae rapidly shorten, the last one being only 3 mm. long. The conch evidently had reached its gerontic stage. The sutures of the septa rise highest laterally, forming relatively low and broad lateral saddles. Dorsally they curve downward only about 3 mm., but ventrally almost 8 mm., at the top of the specimen. The ventral side of the siphuncle increases its distance from the nearest wall of the conch from 5 mm. at its base to 8 mm. at its top. The center of the siphuncle shifts in the same direction. The dorsoventral diameter of the connecting rings decreases from an estimated diameter of 10 mm. at its base to 8 mm. at its top, the vertical outlines of these rings being more strongly convex along the lower part of the specimen, and less convex farther up. The septal necks average about 5.5 mm. in diameter and 2.5 mm. in length, their lower parts curving only slightly outward.

Occurrence.—Lebanon, Tennessee; in the Lebanon limestone. Holotype; U. S. National Museum; no. 82223.

## RAYONNOCERAS Croneis

Genotype: *Rayonnoceras solidiforme* Croneis, New Cephalopods from the Fayetteville Shale; Bull. Mus. Comp. Zool., Harvard College, vol. 47, p. 343, pl. 1, figs. 1–4, 6; pl. 2, figs. 4, 5, 1926.

Actinoceroids with big subventran siphuncles. The septal necks are rather short in comparison with the length of the seg-

ments of the siphuncle. The brim of the necks is distinctly free from contact with the lower side of the septum but is only a short distance from the latter. Segments of the siphuncle broadly nummuloidal, with the greatest diameter slightly above mid-height. From their attachment to the brim of the septal necks the connecting rings spread out horizontally for a short distance and then curve evenly downward toward contact with the septa beneath. The area of adnation of the connecting rings to the upper surface of the underlying septa is very narrow and is almost restricted to the downward curved part of the septum; at any rate, its width is not greater than that of the brim of the underlying septal neck.

The distribution of the American species, as far as known at present, is in the Mississippian of Arkansas and Oklahoma. In Europe it appears to be represented by *Actinoceras giganteum* Sowerby, and *Actinoceras pyramidatum* M'Coy, from the Carboniferous limestone of England, Ireland, and Belgium, as figured by Barrande.[25]

### 29. **Rayonnoceras bassleri** Sp. nov.

*Plate LII, figs. 1A, B; plate LIX fig. 4*

Specimen 220 mm. long, enlarging from a lateral diameter of 23.5 mm. at its base to 63 mm. at a point 160 mm. farther up. Its dorsoventral diameter at this upper point is estimated at 53 mm. Its cross-section is transversely elliptical, with the ventral side only slightly less convex than the dorsal one, if there is any difference at all. Six camerae occur in a length equal to the lateral diameter of the conch at the top of the series of camerae counted, where this diameter is 54 mm., varying to 5.6 camerae where this diameter is 61 mm. The sutures of the septa curve distinctly downward along the ventral half of the conch, but only slightly downward on its dorsal half, in both cases in a ventrad direction. The center of the siphuncle is 22 mm. from the ventral wall of the conch where the dorsoventral diameter of

[25] Barrande, Joachim, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, 1874; Actinoceras giganteum, pl. 235; Actinoceras pyramidatum, pls. 232, 234.

the latter is 53 mm. The diameter of the siphuncle here is 22 mm., narrowing to 11.5 mm. at the septal necks. The latter curve slightly downward on approaching the passage of the siphuncle through the neck, the length of these necks equalling 1.5 mm. The connecting rings are in contact with the upper face of the immediately underlying septa for a width of 4 mm. ventrally, and of 3 mm. dorsally. The shell is 1 mm. thick, and its surface is faintly striated transversely.

Occurrence.—The original label of this specimen being lost nothing definite can be stated as to the locality from which it was obtained or the horizon to which it belongs. However, in its structure and its lithological character it is so closely similar to specimens described by Croneis from the Fayetteville shale of Arkansas under *Rayonnoceras* that it suggests a similar origin, both as to horizon and locality. Hence it is regarded as of Mississippian age. Since no trace of the matrix remains, the entire interior of the conch being calcified, no more definite horizon may be assigned. The remarkably good preservation of the exterior of the shell suggests that it may have come from the interior of some nodule in a shaly deposit, but no trace of either nodule or shale is preserved. Specimen no. 82216, U. S. National Museum; holotype.

Remarks.—*Rayonnoceras bassleri* differs from *Rayonnoceras solidiforme*, the genotype, chiefly in the course of its septa. In *Rayonnoceras solidiforme* these extend horizontally outward for a certain distance from the dorsal side of the septal foramen; whereas, in *Rayonnoceras bassleri* they rise immediately upward from this foramen. There is also a slight difference in the proportions of the segments of the siphuncle. In the genotype these segments appear to be a little flatter than in *Rayonnoceras bassleri*. However, since the holotype of *Rayonnoceras solidiforme* consists of a fragment of the conch belonging nearer to the living chamber than the upper part of *Rayonnoceras bassleri*, and since the siphuncle of many genera of actinoceroids is known to vary in its proportions on approaching the living chamber, no exact comparison between these two species, based upon differences in form of the segments of the siphuncle can be made.

This species is named in honor of Ray S. Bassler, curator of the

department of geology in the U. S. National Museum, in recognition of his broad acquaintance with the Paleozoic paleontology of America.

### 30. **Rayonnoceras buffaloense** Sp. nov.

*Plate XLVIII, figs. 2A, B*

Specimen 50 mm. long, with a lateral diameter of 42 mm. at its top. The center of the siphuncle is 22 mm. from the dorsal wall of the conch at the top and 19 mm. at the base of the specimen. The diameter of the segments of the siphuncle is 16 mm. at the top and 14 mm. at the base. The septal necks are not more than 1 mm. long and the septa are deeply concave. The ventral wall of the conch is not preserved, but the segments of the siphuncle occupy such an oblique position that the location of the siphuncle is supposed to be very near the ventral wall of the conch. The uppermost segment of this siphuncle is 9 mm. high, whereas the height of the second segment above the base of the specimen is 7.5 mm. The area of adnation of the connecting ring with lower surface of the overlying septum is extremely narrow. In the immediate neighborhood of the septal necks the septa are destroyed, so that it can not be determined whether they rise immediately on leaving the dorsal side of the siphuncle or first are horizontal for a short distance.

Occurrence.—Near the west end of Buffalo Mountain, Oklahoma. From boulders in the Caney shale. This shale is of Pennsylvanian age, but the boulders are regarded by Dr. E. O. Ulrich as of Mississippian age, belonging approximately to about the same horizon as the St. Louis. Holotype; no. 82220; U. S. National Museum.

Remarks.—This species differs from *Rayonnoceras vaughanianum* (Girty) mainly in the extreme shortness of its septal necks and in the obliquity of the segments of its siphuncle. The destruction of the septa in the vicinity of the septal necks apparently is due to the pressure produced by the growth of secondary calcite crystals within the camerae. There is no reason for assuming that these fillings of the camerae were present already during the lifetime of the animal, as apparently assumed by Croneis

during his studies of *Rayonnoceras*. Otherwise the septa would not be broken.

### 31. **Rayonnoceras girtyi** Sp. nov.

*Plate XLIX, figs. 1A, B; plate L, fig. 1*

Specimen nearly 70 mm. long, with a lateral diameter of 97 mm. at its base. There are two camerae, each 16 mm. in height. The concavity of the septa equals 1.7 camerae. The ventral side is distinctly less curved transversely than its lateral sides. The center of the siphuncle is 42 mm. from this ventral side. Four segments of the siphuncle are exposed, the height of their connecting rings increasing from 12.5 mm. at the base of the specimen to 14 mm. at its top. At this top the diameter of the uppermost connecting ring is 32 mm., the length of the septal neck equalling about 1.5 mm.

Occurrence.—From Oklahoma, probably from the Washita Mountain area, from a boulder in the Caney shale. This boulder is regarded by Dr. E. O. Ulrich as approximately of about the same age as the St. Louis limestone, in the Mississippian. Holotype; no. 82221; U. S. National Museum.

Remarks.—This specimen differs from typical *Rayonnoceras vaughanianum* in having relatively shorter segments of the siphuncle, the ratio of the length of these segments to their diameter equalling about 0.45, instead of 0.70 as in the latter species.

This species is named in honor of George H. Girty, in recognition of numerous studies on the Carboniferous formations of America.

### 32. **Rayonnoceras vaughanianum** (Girty)

*Plate XLVIII, fig. 1*

*Actinoceras vaughanianum* Girty, Fauna of the Caney shale of Oklahoma, Bull. 377, U. S. Geol. Surv., 1909, p. 48, pls. 7, 8, 9.

Specimen 178 mm. long, enlarging from a lateral diameter of 92 mm. at its base to 110 mm. at a point 140 mm. farther up. Only a little more than one half of the conch is preserved and this

is supposed to be its ventral half. Apparently the cross-section originally was not far from circular, with a moderate amount of depression, and this mostly along its ventral side. Five camerae occur in a length equal to the lateral diameter of the conch. The sutures of the septa are nearly directly transverse. The concavity of the septa at the top of the specimen equals the height of at least 1.5 camerae. The center of the siphuncle is located 45 mm. from the ventral wall of the conch. At 50 mm. from the top of the specimen the maximum diameter of one of the segments of the siphuncle is 31 mm., contracting to 11.5 mm. at the septal necks, the height of this segment being 20.5 mm., and the length of the septal neck equalling 2 mm. The lower face of the connecting rings is in contact with the septum beneath for a width of 3 mm. from the septal foramen. The inner ends of the septal necks curve slightly downward. The surface of the cast of the interior of the shell is smooth.

Occurrence: Hill on east side of Oil Spring crossing of Hickory Creek, in the Washita mountain area of Oklahoma; from boulders in the Caney shale, these boulders being regarded by Dr. E. O. Ulrich as of Mississippian age, approximately corresponding to the St. Louis. No. 82217; U. S. National Museum.

A second specimen, from Johns Valley in the Washita mountain area of Oklahoma, has a lateral diameter of 88 mm. at its top. Here the center of the siphuncle is 49 mm. from the dorsal wall of the conch, showing that the location of the siphuncle is distinctly ventrad of the center of the conch. No. 82218; U. S. National Museum.

Remarks.—This species is placed in *Rayonnoceras* on account of the outline of its siphuncle and the structure of its septal necks. Carey Croneis[26] states regarding *Actinoceras vaughanianum* that its "camerae are only partially filled by organic deposits, the apical angle is less than in *Rayonnoceras solidiforme*, the sutures are straighter, the shell not only is thicker but lacks striae, and the concavity of the septa is less."

[26] Croneis, Carey, Bull. Mus. Comp. Zool., Harvard College, vol. 67, p. 348, 1926.

### 33. **Rayonnoceras** cf. **vaughanianum** (Girty)

*Plate LI, fig. 1*

Specimen 220 mm. long. In its present condition it is badly flattened and weathered but it shows the siphuncle well. The present width of the conch is 110 mm. Eight segments of the siphuncle occupy a total length of 190 mm. The best preserved of these segments is 23 mm. long and 35 mm. wide, which gives a ratio of 0.66 between its length and its diameter, a ratio which is comparable with that presented by *Rayonnoceras vaughanianum* as here identified.

Occurrence.—Specimen without a label; probably from some locality in Oklahoma. Judging from the presence of fragments of *Productus*, it is at least of Carboniferous age, and is assumed to have been obtained in the Mississippian. The matrix also contains unidentifiable fragments of some species of *Spirifer*. No. 82219; U. S. National Museum.

## **SAFFORDOCERAS** Gen. nov.

Genotype: *Saffordoceras nelsoni* Foerste and Teichert.

Conch straight and actinoceroid. Its ventral side evidently is flattened, but nothing is known of its lateral or dorsal outline. The sutures of the septa curve strongly downward along the greater part of the width of the conch, but form saddles before reaching its lateral outlines in a manner similar to those of *Gonioceras*, but apparently narrower. Apparently these sutures do not sweep strongly downward on approaching the lateral margins of the conch, as in that genus, but it must be remembered that the lateral outlines of the only specimen of *Saffordoceras* at hand are not clearly preserved. The siphuncle apparently presents septal necks of sufficient length to include this genus among the Actinoceratidae. It is located close to the ventral wall of the conch at its lower end, but apparently becomes more distant farther up. In the diminution of the diameter of the siphuncle with increasing age it shows another feature common among the Actinoceratidae.

This genus is named in honor of James Merrill Safford, the founder of our more exact knowledge of the geology of Tennessee.

### 34. **Saffordoceras nelsoni** Sp. nov.

*Plate LIII, fig. 1*

*Orthoceras capitolinum* Safford, Geology of Tennessee, 1869, pl. 4, fig. 1c (not figures 1a, 1b).

Specimen 132 mm. long. At a point 75 mm. below its top the lateral diameter of the conch is estimated at 70 mm. The rate of enlargement of the conch can not be determined. Its cross-section is distinctly flattened ventrally, its transverse curvature here being much less than ventrolaterally; however, no part of the dorsal side is exposed. Where the lateral diameter of the conch is 70 mm., 5 camerae occupy a length of 25 mm. At its top, the spacing of the segments of the siphuncle indicates the presence of 5 camerae in a length of 30 mm. The sutures of the septa curve downward along the median part of the ventral side of the conch for a width of 50 mm. and for a depth of 12 mm. at a point a little below mid-height of the specimen. At points about 26 or 27 mm. from the median line of this ventral side, the sutures of the septa curve moderately downward ventrolaterally. The siphuncle appears to be almost in contact with the ventral wall of the conch, but its connecting rings present no trace of flattened contact areas. At a point 100 mm. below the top of the specimen the connecting ring is at least 18 mm. in diameter. At 40 mm. beneath its top this diameter is 13 mm., and this smaller diameter is retained from the point mentioned as far up as the top of the specimen. The relatively rapid diminution of the diameter of the siphuncle for a length of 60 mm., therefore, is followed by a continuation of the smaller diameter for the remainder of its length. Apparently the upper part of the siphuncle is more distant from the ventral wall of the conch than its lower part, judging from the ventral outline of the lower part of the specimen. The connecting rings of the siphuncle slope distinctly downward in a dorsad direction, as might be expected from their close proximity to the ventral wall of the conch. The intervening septal necks appear to be between 1 and 1.5 mm. in length along the lower part of the siphuncle. Farther up they appear to have been at least 2 mm. long, and along the ventral side of the siphun-

cle lengths of even 3 mm. appear to exist. However, these intervals between the connecting rings may be due partly to imperfect preservation of the deposits lining the inner walls of these rings, only their more interior parts being well preserved.

Occurrence.—Nashville, Tennessee; from some part of the Catheys; imbedded in a very fine-grained brownish limestone. Holotype; no. 82224, U. S. National Museum. This species is named in honor of W. A. Nelson, formerly state geologist of Tennessee.

Remarks.—As already stated under *Actinoceras capitolinum*, this specimen, the upper end of whose siphuncle closely resembles Safford's figure 1c, apparently came from an entirely different horizon from the specimens represented by his figures 1a and 1b. According to Foord, in his Catalogue of the Fossil Cephalopoda in the British Museum, published in 1888, this museum contains a fragment of a siphuncle which Foord regarded as identical with the one figured by Safford, and the accompanying label bears upon it the same name and locality, but Foord regarded it as not proved that this fragment of a siphuncle belonged to Safford's species *Orthoceras capitolinum* as represented by his figures 1a and 1b, and we feel even more certain as to their distinctness.

## **TROOSTOCERAS** Gen. nov.

Genotype: *Troostoceras paulocurvatum* Foerste and Teichert

Actinoceroids with slightly convex ventral outlines, at least along the lower part of the conch; the upper part may have been straight, or nearly so. Cross-section apparently approximately circular. Sutures of septa curving strongly downward ventrally. Siphuncle in contact with the ventral wall of the conch and presenting relatively large contact areas. Siphuncle enlarging gradually from a lateral diameter of 7 mm. at the smallest segment known to about 17 mm. and then retaining about the same size or diminishing moderately in diameter farther up.

Known at present only from the Bigby member of the Trenton in Tennessee.

The length of the septal necks places *Troostoceras* among the typical Actinoceratidae. It differs from *Actinoceras* chiefly in

the convex curvature of the lower part of its ventral outline. Moreover, it differs from typical *Actinoceras*, in enlarging gradually from a narrow apical end, while the most apicad parts of *Actinoceras* at present known are large and blunt, with the septum at the base rising obliquely upward in a dorsad direction. In addition there is a downward directed large and blunt protuberance, representing the downward continuation of the calcareous deposits filling the interior of the siphuncle, and this protuberance is pierced by a conspicuous opening which is a downward continuation of the endosiphon occupying the interior of the siphuncle. Nothing comparable with this structure is known in the case of *Troostoceras*.

This genus is named in honor of Gerard Troost, the pioneer in the study of the geology of Tennessee, and long the State Geologist of that state.

### 35. **Troostoceras paulocurvatum** Sp. nov.

*Plate LIV, figs. 1A, B, C; plate LIX, fig. 5*

Specimen 122 mm. long, slightly curved lengthwise along its lower half. Here the radius of curvature along its convex ventral outline is 200 mm. Along its upper half this outline may be straight; at least no distinct curvature is noted here. In its present condition the cross-section of the conch appears circular, although its wall is crushed in along part of the upper half of the left side of the siphuncle. At a point 100 mm. above the base of the specimen the lateral diameter of the conch is estimated at 40 mm. The conch may have enlarged at an angle of 10 degrees, but this is uncertain. There is very little variation in the height of the camerae along the entire length of the specimen. Judging by the height of the segments of the siphuncle at its base, 5 camerae here occupied a length of 33 mm., and at its top a corresponding number occupy a length of at least 31 mm. The siphuncle is in contact with the ventral wall of the conch along the entire length of the specimen, the width of the contact area being about 11 to 13 mm., except along its lower 2 segments, where it is less. However, a smaller height of the intervening septal necks remains free from contact along the lower part of the

siphuncle than farther up. The lateral diameter of the siphuncle increases from 12 mm. at its base to 16 mm. at the seventh segment above this base. The result is that the upper segments of the siphuncle appear more broadly nummuloidal than the lower ones, as far as exposed. The septal necks vary in length from 1.5 mm. between the lower segments to slightly over 1 mm. at the upper end of the exposed part of the siphuncle.

Occurrence.—Nashville, Tennessee; in the Bigby member of the Trenton. Holotype; specimen no. 83053, U. S. National Museum.

Remarks.—At first glance, *Troostoceras paulocurvatum* bears some resemblance to the specimen here described as *Actinoceras capitolinum*. The seventh segment above the base of the exposed part of the former closely resembles in size and lateral outline the lower segments preserved by the holotype of the latter. Moreover, in both specimens the ventral side of the connecting rings is distinctly flattened by contact with the adjacent parts of the conch, and in both the sutures of the septa curve strongly downward ventrally. However, in *Actinoceras capitolinum* the cross-section of the conch is distinctly and broadly flattened ventrally, and is not approximately circular as in *Troostoceras paulocurvatum*. Moreover, the ventral lobes formed by the downward curvature of the sutures of the septa in the latter are relatively broader. Finally, the ventral outline of its long siphuncle is straight, and shows no trace of curvature. However, if the curvature of the ventral outline of *Troostoceras* is confined to its lower end, the absence of such curvature in the holotype of *Actinoceras capitolinum* has no direct bearing, since this holotype does not retain any part of its apical end.

36. **Troostoceras paulocurvatum abbreviatum** Var. nov.

*Plate LIV, figs. 2A, B*

Specimen 73 mm. long, consisting of a siphuncle closely resembling the exposed part of the siphuncle of the holotype of *Troostoceras paulocurvatum* in the moderate curvature of the lower part of its convex ventral outline, in its rate of enlargement along the lower 7 segments of the siphuncle, and in the relative

size and lateral outline of these segments. It differs from the holotype mentioned, however, in enlarging from a lateral diameter of 14.5 mm. at the second segment above its base to 17 mm. at the sixth, seventh, and eighth segments, and then diminishing to 15 mm. at the eleventh segment. Moreover, the length of the septal necks along the lower part of the specimen is somewhat greater. As in the holotype of the species, the ventral side of the siphuncle was flattened at contact with the adjacent wall of the conch, the flattened areas being larger along the lower connecting rings than toward the upper end of the specimen. The lower connecting rings are at right angles to the vertical axis of the siphuncle or rise slightly in a dorsad direction, but the upper rings slope distinctly downward in that direction.

A second fragment of a siphuncle, 29 mm. in length, appears to belong to a more apicad part of the latter. In this specimen the smallest segment has a lateral diameter of 6.5 mm., the diameter of the fifth being 11 mm. The contact areas on the ventral side of these segments are distinctly flattened.

Occurrence.—From some unknown locality and horizon in Tennessee; assumed to be from the vicinity of Nashville, and from the Bigby member of the Trenton. The larger specimen is selected as the holotype of this variety, and is one of a series numbered 82230, in the U. S. National Museum.

Remarks.—The chief interest in this variety is in the evidence which it presents that the curvature of the lower part of the ventral outline of the conch is a characteristic of the species, and not only of a single individual.

## **ARMENOCERAS** Foerste

Genotype. *Actinoceras hearsti* Parks, Trans. Royal Canadian Inst., vol. 11, 1915, p. 73, pl. 6, fig. 5; *Armenoceras hearsti* Foerste, Contrib. Mus. Geol., Univ. Michigan, vol. 2, 1924, p. 32, pl. 13, fig. 4; Jour. Sci. Lab. Denison Univ., vol. 22, 1927, p. 68, pl. 8, fig. 4; pl. 24, fig. 5.

In the genotype the siphuncle is relatively large, strongly nummuloidal, and located close to the ventral wall of the conch. The segments of the siphuncle are strongly contracted at the

septal necks, and these necks are very short, equalling about seven or eight tenths of a millimeter on the dorsal side of the siphuncle and about six or seven tenths on its ventral one. The brim is strongly and abruptly recurved, its width varying in different necks from slightly less than one millimeter to one and a half millimeters, and in several cases possibly equalling two millimeters. On the dorsal side of the siphuncle the brim appears to be from two to three tenths of a millimeter distant from the overlying part of the septum, diminishing to slightly over one tenth of a millimeter at its nearest approach to the septa on the ventral side of some of these necks. The septa are not distinctly preserved so as to be definitely distinguishable from the walls of the overlying connecting rings. The outlines of the walls of the connecting rings, on the contrary, usually are clearly defined. The septa are adnate to the lower face of the overlying rings for a width of 8 mm. along the dorsal side of the siphuncle, and from 10 to 12 mm. ventrally. Along the ventral side of the siphuncle the outer part of the lower face of the connecting rings tends to be faintly concave, as in *Huroniella,* but there is no corresponding curvature along its dorsal outline.

In most other species hitherto referred to *Armenoceras* the brim is definitely not in contact with the lower face of the septum from which it originates. In *Armenoceras richardsoni,* however, not only the brim but also the upper face of the adjacent connecting ring is in contact with the lower surface of the overlying septum (Plate XLIII, fig. 1B).

*Armenoceras* is widely distributed over the northern half of the North American continent and the American Arctic Archipelago. It ranges there from the Red River formation upward into the overlying Silurian. It occurs in the normal Richmond. In central Tennessee it is found in the Catheys, which is the highest formation of Trenton age in that state. Specimens resembling *Armenoceras* appear to occur in still older strata in Corea, Manchuria, and Northern China.

In northwestern Europe this genus is represented by *Armenoceras cochleatum* (Schlotheim), *Armenoceras lamellatum* (Angelin), and *Armenoceras imbricatum* (Hisinger) on the island of Gotland,

off the southeastern coast of Sweden, the species named last occurring also on the island Oesel, west of the mainland of Esthonia. In Great Britain this genus is represented by *Armenoceras subconicum* (d'Orbigny) and *Armenoceras nummularium* (Sowerby). In Bohemia it is represented by *Armenoceras docens* (Barrande), which during the normal growth of the conch has an armenoceroid form of siphuncle, but which during its gerontic stages changes the form of the segments of its siphuncle from broadly nummuloidal to nearly spherical. All of the European species here mentioned belong to the Middle Silurian, as though the genus had developed originally west of the Atlantic and had spread thence eastward into the epicontinental seas invading the northwestern parts of Europe.

In a similar manner the genera *Huronia* and *Huroniella* are known in America already in the Clinton. Early forms of *Huronia* occur in Manitoba, in the area southwest of Hudson Bay, and in Northern Greenland already in the Red River formation. In Europe the only representative of this group is the species described by Troedsson[27] under the name *Huroniella vasiforme* from the Arachnophyllum bed of Llandovery age, which also is Silurian.

### 37. **Armenoceras brevicameratum** Sp. nov.

*Plate XLIV, figs. 1A, B; plate LVIII, fig. 2*

Specimen 93 mm. long, enlarging from a lateral diameter of 53 mm. at its lower end to 68 mm. at its top, the corresponding dorsoventral diameters being 48 mm. and 59 mm. Five camerae occupy a length of 25 mm. at the lower end of the specimen, but only 21 mm. at its upper end, the specimen probably being a fragment from the upper end of a phragmacone. The sutures of the septa slant downward in a ventrad direction at an angle of 8 degrees with the horizontal. The concavity of the septa equals the height of 3 camerae. The center of the siphuncle is located 14 mm. from the ventral wall of the conch where its dorsoventral

[27] Troedsson, Gustaf, On the appearance of Huronia-like cephalopods in the Baltic Silurian, Arkiv for Zoologi, vol. 19A, no. 3, 1926, p. 5, pl. 1.

diameter is 59 mm. Its diameter is almost 19 mm., contracting to 9 mm. at the septal necks. These necks curve abruptly outward and become adnate to the lower face of the septa from which they originate.

Occurrence.—Nashville, Tennessee, in the City quarry near the City hospital, in the Catheys. Holotype; U. S. National Museum, no. 82222.

Remarks.—This species shows resemblance to *Nybyoceras* in the fact that the connecting rings of its siphuncle are in contact with the septa below on the ventral side of the specimen, and with the septa above on its dorsal side. It is distinguished from typical *Nybyoceras* in the extreme shortness of the segments of its siphuncle, thereby destroying any external resemblance between the siphuncles. As in the case of *Ormoceras covingtonense*, a species only provisionally put in the genus *Ormoceras*, certain characteristics distinctive of *Nybyoceras* are missing, and we wish here to call attention to the fact that all siphuncles with an armenoceroid siphuncle are more or less liable to develop a Nybyoceras-like type of contact between the connecting ring and the septa, if located in a distinctly excentric position.

### 38. **Armenoceras madisonense** Sp. nov.

*Plate XLV, figs. 1A, B, C; plate LVIII, fig. 1*

Specimen 135 mm. long, enlarging approximately at a lateral angle of 5 degrees. At its base the lateral diameter is estimated at 35 mm., and at a point 90 mm. farther up it equals 43 mm. The number of camerae in a length equal to the lateral diameter of the conch varies from 6 along the lower part of the specimen to 7 near its top. The concavity of the septa is about 8 mm. The sutures of these septa are not exposed. The siphuncle is in flattened contact with the ventral wall of the conch along the lower end of the specimen, but is 1.5 mm. distant at its upper end. The diameter of the siphuncle enlarges from 18 mm. at the base of the specimen to 20 mm. at its top. The septal necks are extremely short, and hardly twice as long as the thickness of one septum. The septa curve backward very sharply at the septal foramen and form a rather short brim. Along its inner part the

brim is separated for a very short distance from the lower side of the overlying septum, but comes in contact with this septum along its outer half.

Occurrence.—Madison, Indiana; from some unknown horizon, but apparently from the Saluda member of the Richmond. Holotype; no. 15493, U. S. National Museum.

### 39. **Armenoceras richardsoni** (Stokes)

*Plate XLIII, figs. 1A, B*

*Actinoceras richardsoni* Stokes, Trans. Geol. Soc. London, ser. 2, 5, pt. 3, 708, pl. 59, figs. 2, 3 (1840); Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 83, pl. 9, figs. 2, 2a (1892).

*Armenoceras richardsoni* Foerste, Jour. Sci. Lab., Denison Univ., 23, 75, pl. 21, fig. 1 (1928); 24, 202, pl. 32, figs. 1A, B (1929).

The specimen here figured consists of a large siphuncle 140 mm. long, and with a lateral diameter of 52 mm. along its entire length. The height of all of its segments is about 15 mm. This specimen is figured here to show the internal structure of this species which differs from that of typical *Armenoceras*. The calcareous deposits in the interior of the siphuncle leave a large funnel-shaped cavity in its center, similar in form to an endocone, slowly decreasing in diameter toward its lower end, and having rather smooth walls. This is unusual for a member of the genus *Armenoceras*, and reminds somewhat of the interior of the siphuncles of *Narthecoceras*.

The septa are strongly recurved on their inner margin and the recurved brim is comparatively broad. This brim can scarcely be distinguished in a simple vertical cut through the siphuncle, but is clearly recognizable in a thin section. On approaching the septal foramen the septum becomes thinner, especially close to this foramen, and then curves back very sharply at the inner margin of the septal neck. The recurved part, or brim, is in contact with the lower side of the septum along its inner part, but toward its outer margin it becomes free from contact, though separated only for a very short distance from the overlying septum. The total thickness of the inner part of the septum plus that part of the brim which is in actual contact with the latter

is about the same as that of the septum alone along its outer parts, so that the recurvature of the septal neck, here called a brim, is not likely to be detected at all in the absence of translucent sections.

Occurrence.—Lower Fort Garry, Manitoba; in the Selkirk limestone of the Red River formation. The figured specimen is numbered 4761 in the U. S. National Museum. The thin section (Plate XVII, fig. 1B) is numbered 4761B.

Remarks.—This specimen shows some resemblance to *Westonoceras* in the shortness of its septal necks and in the close contact between the inner part of the brim and the lower side of the overlying septum, only the outer part of this brim becoming free. Another difference from typical *Armenoceras* consists in the different character of the calcareous deposits within its siphuncle.

Compared with *Nybyoceras*, the area of adnation of the upper side of the septa to the overlying connecting rings is wider, and extends dorsally as well as ventrally, differing altogether in the latter respect.

## **ELRODOCERAS** Foerste

Genotype: *Cyrtoceras indianense* Miller, 17th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1892, p. 698, pl. 18, figs. 1, 2; Foerste, Contrib. Mus. Geol. Univ. Michigan, vol. 2, 1924, p. 65; Jour. Sci. Lab., Denison Univ., vol. 20, 1924, p. 228, pls. 35–38; vol. 21, 1925, pl. 24, fig. 2.

Conchs actinoceroid, cyrtoconic at their base, but relatively straight farther up. Siphuncle ventrad of the center of the conch. Segments of the siphuncle presenting moderately convex vertical outlines laterally, but their upper and lower surfaces, where in contact or almost in contact with the intervening septa, are relatively flat, so that these segments present more or less barrel-like outlines. The septal necks are very short, but their brim is so abruptly recurved, and so closely applied to the lower surface of the septum from which it originates that its presence was not discovered until a thin translucent section was made by the junior author of a specimen of *Elrodoceras indianense* (Miller),

the genotype, obtained from the Laurel limestone at St. Paul, Indiana, numbered 82240 B, in the U. S. National Museum. In this specimen (Plate XLVII, fig. 1) the course of the septa becomes nearly horizontal as soon as they come in contact with the connecting rings. On their inner margin, at the septal foramen, they slope downward a little and then curve sharply backward so that the brim at first is in contact with the lower side of the septum and then, toward its margin, becomes free from contact with the septum, ending in a sharp rim, which, in the vertical translucent section, appears as a narrow tip. The brim is very short, and not longer than the downward sloping part of the septum. Since this inner part of the septum is a little thinner than its more distant parts, the total thickness of this inner part plus the brim is only a little thicker than the more distant part of the septum. Owing to this small total thickness the presence of a recurved brim easily escapes attention, except in translucent sections.

The surface of the shell of the conch is striated or narrowly banded transversely, somewhat as in *Geisonoceras*, but the bands are much narrower than in typical *Geisonoceras*. These striae or bands curve downward slightly along the ventral side of the conch, thus locating the shallow, but distinct hyponomic sinus.

There is a possibility that the species here described as *Westonoceras* (?) *rallsense* may be more closely related to *Elrodoceras* than to *Westonoceras*. At least it appears to have been curved at its lower end, but the evidence for this is not altogether satisfactory, and its horizon is so much lower than that of all other species of Elrodoceras known so far that its actual reference to *Elrodoceras* appears unwarranted. At the same time it is not a typical *Westonoceras*.

### 40. **Elrodoceras osmanense** Sp. nov.

*Plate XLVII. fig. 3*

Specimen 70 mm. long, represented only by a vertical section through the center of the siphuncle. Its present lateral diameter enlarges from 28 mm. at the base of the specimen to 37 mm. at a point 60 mm. farther up. The number of camerae in a length equal to the lateral diameter is 4. The concavity of the septa

equals 8 or 9 mm. at the top of the specimen. Where the lateral diameter of the specimen is 34 mm., that of the siphuncle is 12 mm. From this diameter the segments narrow to 8 mm. where they come in contact with the septa, and to 5 mm. at the passage of the siphuncle through the septa. The vertical outlines of these segments is moderately convex. Both the connecting rings above and below the septa are in contact with the inner margin of the septa around the septal necks for a width of nearly 1.5 mm. The inner ends of the septa curve slightly downward. The area of contact between the ends of the connecting rings and the intermediate septa is not as broad as in typical *Elrodoceras*. In other respects the structure of the siphuncle of this species agrees closely with that of the genus named.

Occurrence.—East of West Union, Ohio; half a mile northeast of the Osman school; in the Dayton limestone member of the Clinton. Holotype; no. 81920, U. S. National Museum.

Remarks.—In typical *Elrodoceras*, the apical end of the conch is curved as in a cyrtoceroid, and the shell is striated transversely, the striae curving downward ventrally. In the specimen here described the presence or absence of these features can not be determined.

### 41. **Elrodoceras telleri** Sp. nov.

*Plate XLVII, fig. 2; plate LVIII, fig. 12*

Species differing from typical *Elrodoceras abnorme* chiefly in the shorter and more numerous camerae at earlier stages of growth, and in its relatively smaller siphuncle.

Specimen 95 mm. long, slightly curved at its base, the convexly curved side being regarded as ventral. Its dorsoventral diameter enlarges from 32 mm. at the third camera above the base of the specimen to 44.5 mm. at a point 63 mm. farther up. The number of camerae within a length equal to the diameter of the conch equals 5 along the upper end of the specimen. Where the diameter of the conch is 40 mm., that of the siphuncle is 13.5 mm. or about one-third of that of the conch. The passage of the siphuncle through the septum is only slightly larger than 7 mm. The connecting rings evidently were in contact with the intermediate septa as in typical *Elrodoceras*.

Occurrence.—Racine, Wisconsin; in the Racine dolomite of the Niagaran. Holotype; U. S. National Museum; no. 82239.

Remarks.—This species is named in honor of Edgar E. Teller, for many years a most industrious collector of the Silurian and Devonian fossils of Wisconsin.

## **NYBYOCERAS** Troedsson

Genotype: *Actinoceras* (*Nybyoceras*) *bekkeri* Troedsson. On the Middle and Upper Ordovician faunas of Northern Greenland. Jubilaeumsekspeditionen Nord om Grønland 1920–23, no. 1, 106, pl. 63, figs. 1–3 (1926). See also C. Teichert, Die Cephalopoden-Fauna der Lyckholm-Stufe; Pal. Zeitschrift, vol. 12, pl. 6, figs. 7–8, pl. 7, fig. 19 (1930).

Orthoceracones with large siphuncles. In the more typical species the siphuncle is located close to the ventral wall of the conch, if not in contact with the latter; however, in *Nybyoceras intermedium* Teichert, from the Lyckholm formation of Esthonia, the location of the siphuncle is only slightly ventrad of the center of the conch. The septal necks resemble those of *Armenoceras* in their shortness and strong recurvature. On the ventral side of the siphuncle the septa usually are in broad contact with the base of the overlying ring, while on its dorsal side they are in contact for a similar width with the underlying ring. On the contrary, the contacts between the septum and the ventral side of the underlying connecting ring, and between this septum and the dorsal side of the overlying ring are very narrow and almost absent. The form of the septal necks in all of the species known at present is essentially identical.

This genus makes its first appearance in the Lower Chazyan of Oklahoma, where it is represented by *Nybyoceras ulrichi* in a fauna having Pacific relationship. The next occurrence, as far as known, is that of *Nybyoceras foerstei* Endo, in the Upper Chazyan of South Manchuria, on the western side of the Pacific. In Esthonia, in the Baltic areas of Europe, three species occur at a much higher horizon, namely in the Lyckholm beds. Two of these species, *Nybyoceras bekkeri* Troedsson and *Nybyoceras balticum* (Troedsson), were described already in 1926, the latter

under the name *Megadiscosorus balticum* Troedsson (Ibid, 107, pl. 61, fig. 4; pl. 63, fig. 4; pl. 64, fig. 3, 1926). The third species, *Nybyoceras intermedium* Teichert, was described recently in the publication cited above. The general distributon of these species suggests a northern origin of the genus.

The extreme shortness of the septal necks of *Nybyoceras* suggests that the relationship of this genus is much closer to *Armenoceras* than to *Actinoceras*, the septal necks of the latter being much longer. For this reason we refer *Nybyoceras* to the family Armenoceratidae, proposed by Troedsson on page 60 of the publication cited above, instead of placing it among the Actinoceratidae, as was done by Troedsson, on page 52 of the same publication.

In the present state of our knowledge of *Nybyoceras* it appears necessary to restrict the application of this generic name to those species which possess siphuncles comparable to those of the genotype both in structure and size. This excludes a number of actinoceroid species which are similar to *Nybyoceras* in having the septa in contact with the ventral side of the overlying segments of the siphuncle, and with the dorsal side of the underlying segments, as in the three species here referrred to *Ormoceras* on account of their much smaller siphuncles, the three being *Ormoceras covingtonense*, *Ormoceras dismukesense*, and *Ormoceras lindsleyi*. It should be observed, however, that this reference to *Ormoceras* is only tentative, typical representatives of that genus not having the lower side of the septa in contact with the upper face of the underlying connecting rings, either dorsally or ventrally.

### 42. **Nybyoceras ulrichi** Sp. nov.

*Plate XLVI, figs. 1A, B, C*

Specimen 58 mm. long, probably circular in cross-section, 53 mm. in diameter at its base, and apparently enlarging slowly. The number of camerae in a length equal to the diameter of the conch is 7. The sutures of the septa slope downward from the ventral toward the dorsal side of the conch, resulting in shallow dorsal lobes. The concavity of the septa equals about 9 mm.,

the maximum concavity being dorsad of the center of the conch. The siphuncle is 19 mm. in diameter, and equals 0.35 of the diameter of the conch. Its connecting rings evidently were close to the ventral wall of the conch, but it can not be determined whether they were about 1 mm. distant or in actual contact with the latter. The dorsal side of the septal neck is 1 mm. in height, the neck being constricted here to a diameter of 8 mm. On this side of the neck the adjacent part of the septum is in contact with the overlying connecting ring for a width of 1.5 mm. The recurved part of the septal neck rises sufficiently to come in contact with the lower surface of the septum itself at a point 2.5 mm. from the most contracted part of the neck. The top of the underlying connecting ring is in contact with the lower surface of the septum from a point 2.5 mm. from the most contracted part of the neck to a point 5.5 mm. distant from the latter. On the lateral side of the siphuncle the inner part of the septum is in contact with the overlying connecting ring for a width of 4 or 5 mm. from the narrowest part of this neck, and along the ventral side of the siphuncle it may have been in contact with this overlying ring for a still greater distance.

Occurrence.—North of Springer, in Carter county, Oklahoma; on state road no. 4. In the Simpson group, in strata 100 feet below the third sandstone, of Lower Chazyan age. Holotype; specimen no. 82227; U. S. National Museum.

Remarks.—Compared with the genotype, *Nybyoceras bekkeri* Troedsson, from the Lyckholm beds (F 1) at Nyby, in Esthonia, there are 2.5 camerae (instead of 2) in a length equal to the diameter of the siphuncle; and the septa continue to slope downward from the dorsal side of the siphuncle at least as far as the center of the conch before rising toward the dorsal wall of the latter (instead of rising immediately after becoming free from contact with the underlying connecting rings). The difference mentioned last is the more important diagnostically.

In *Nybyoceras balticum* (Troedsson), also described from the Lyckholm beds at Nyby, in Esthonia, the connecting rings are relatively of smaller height than in *Nybyoceras bekkeri*, but the septa here also curve upward soon after becoming free from

contact with the upper surface of the dorsal side of the underlying connecting rings.

*Nybyoceras ulrichi* is named in honor of E. O. Ulrich, the Nestor of American paleontologists, whose intimate knowledge of the paleontology of the American Paleozoic, and especially of the cephalopods, he generously placed at the disposal of the writers of this paper.

## **WESTONOCERAS** Foerste

Genotype: *Cyrtoceras manitobense* Whiteaves, Trans. Royal Soc. Canada, vol. 7, sec. 4, p. 80, pl. 13, figs. 3, 4, 5; pl. 15, fig. 4 (1890). *Westonoceras manitobense* Foerste, Jour. Sci. Lab., Denison Univ., vol. 20, p. 253 (1924); Contrib. Mus. Pal. Univ. Michigan, vol. 3, p. 49, pl. 5, fig. 1, pl. 11, fig. 5 (1928); Jour. Sci. Lab. Denison Univ., vol. 24, p. 220, pl. 38, figs. 2, 3 (1929).

Conch faintly concave along the lower part of the dorsal outline, but more or less distinctly convex along the upper part of the phragmacone and the lower part of the living chamber, becoming faintly concave again toward the aperture. Ventral outline convex along its entire length, but especially five or six camerae beneath the living chamber. Cross-section laterally compressed, especially at the level of the maximum diameter of the conch. Upward from this level the conch contracts as far as the aperture. The sutures of the septa curve distinctly downward laterally in the genotype, though nearly straight along most of their course in some of the other species, curving upward only close to the ventral side of the conch along the upper half of the phragmacone. The siphuncle is located close to the ventral side of the conch, but is not in contact with the latter. The lateral sides of the connecting rings are moderately convex, and the upper and lower parts of these rings, where in contact with the intermediate septa, are nearly flat, so that the segments of the siphuncle present the appearance of tiny barrels.

In the vicinity of the siphuncle the septa are horizontal In the immediate neighborhood of the septal foramen they curve very slightly upward and then recurve very sharply and suddenly

downward and outward. The brim, for its entire length, is in close contact with the lower side of the septum, so that, on superficial examination, the presence of the brim is not recognized, and, unless a relatively large magnification is used, the septum merely appears to thicken toward the septal foramen.

In this respect the septal necks of *Westonoceras* present exactly the same appearance as those of the genus *Thuleoceras*, proposed by Troedsson[28] in 1926. The surface markings of the cast of the interior of the shell also are similar in both *Westonoceras* and *Thuleoceras*. Although the upper parts of the conchs called *Thuleoceras* by Troedsson are not known, their lower parts agree so closely, especially in the structure of the septal necks, that *Thuleoceras* must be regarded as a synonym for *Westonoceras*. At the time Troedsson proposed his genus, the exact structure of the septal necks of *Westonoceras* had not yet been determined, and hence he had no means of determining how closely their structure was identical in the two genera.

The genus *Westonoceras* was named in honor of T. C. Weston, for many years a most intelligent and energetic collector of fossils for the Geological Survey of Canada. Unfortunately, through a typographical error, the original spelling of this genus was *Westenoceras*, and it was some time before this error was discovered and corrected.

### 43. **Westonoceras iowense** Sp. nov.

*Plate LV, figs. 2A, B*

Specimen 64 mm. long along its ventral side. The conch is very slightly curved. The sutures of the septa rise rather strongly dorsally and ventrally, the saddles of the sutures being very sharp ventrally. The lowest part of the lateral lobes lies about on the median line of the lateral sides. Along the upper part of the specimen the sutures rise higher ventrally than dorsally. Along its lower part, on the contrary, they rise higher dorsally

[28] Troedsson, Gustaf, On the Middle and Upper Ordovician faunas of Northern Greenland; pt. I, Cephalopods. Jubilaeumsekspeditionen Nord om Grønland, 1920–23; no. 1, 1926, p. 93, pl. 1, figs. 3, 4; pl. 55, figs. 4–9. See also Foerste, Aug. F. Thuleoceras ornatum, Jour. Sci. Lab., Denison Univ., vol. 23, 1928, p. 98. pl. 8, figs. 2-5; pl. 23, fig 8.

than ventrally. The surface of the cast of the interior of the shell is marked by low vertical ribs about 1 mm. wide and 1 mm. distant from each other. The cross-section tends to be angular along the median part of the ventral side but rather evenly rounded along its dorsal side. Where the specimen is 15 mm. wide, the siphuncle is 1 mm. distant from the ventral wall of the conch. The segments of the siphuncle here are 3.5 mm. wide and 2.5 mm. high. The width of the septal foramen only slightly exceeds 1 mm. The segments are broadly expanded, but can not be called nummuloidal, since they are more nearly barrel-shaped in outline. The septa are horizontal in the vicinity of the septal foramen and even curve a little upward in their immediate neighborhood. Then they curve strongly outward, the brim being in contact for its entire width with the lower side of the septum, so that both can hardly be separated. The connecting ring is in contact with the overlying septum for nearly the entire width of the segment of the siphuncle; then it curves angularly downward and runs parallel with the wall of the conch until it reaches the next septum, where it again is in contact with a septum, but on its upper side. The conditions on the dorsal side of the siphuncle are similar, but the connecting ring here is slightly more convex along its lateral outline, and not as straight as ventrally.

Occurrence.—Near mouth of creek 2 miles northwest of Clermont, Iowa; from the Stewartville horizon, just under the Clermont member of the Maquoketa formation. Holotype; no. 83055, U. S. National Museum.

Remarks.—This species differs from the genotype, *Westonoceras manitobense*, mainly in the lesser curvature of the sutures of its septa. The lateral lobes of the sutures are rather shallow and symmetrical, but not as shallow as in *Westonoceras gouldi*.[29] Although the upper part of the conch is not known the structure of its siphuncle indicates its generic relationship.

[29] Foerste, Aug. F., The cephalopods of Putnam Highland, in Contributions to the geology of Foxe Land, Baffin Island, Contrib. Mus. Pal., Univ. Michigan, vol. 3, 1928; Westonoceras gouldi, p. 52, pl. 5, fig. 2; pl. 11, figs. 1A, B, C; Westonoceras manitobense, p. 49, pl. 5, fig. 1; pl. 11, fig. 5.

### 44. **Westonoceras** cf. **iowense** Foerste and Teichert

*Cyrtoceras manitobense* Schuchert, Proc. U. S. National Museum, vol. 22, p. 170, 1900; only the Akpatok island specimens.

*Plate LV, figs. 3A, B, C*

A few fragmentary specimens of *Westonoceras* from Akpatok island, along the southern margin of Hudson Strait, show more resemblance to *Westonoceras iowense* than to any other known species of this genus. The sutures of the septa have the same gentle and symmetrical downward curvature laterally, and also the same ratio between the length of the camerae and their diameter. In a specimen with a dorsoventral diameter of 22.5 mm. the siphuncle is 1.5 mm. distant from the ventral wall of the conch. The septa curve strongly backward at the septal foramen and the brim equals about two-thirds of the width of the area of adnation of the connecting ring with the septa. Although the siphuncle is beautifully preserved and very typical for true Westonoceras, too little of the conch is preserved to use these specimens as types of a new species. However they evidently show a close relationship with *Westonoceras iowense*, and their identity with that species is not impossible.

Occurrence.—Akpatok Island, at the northern end of Ungava Bay, along the southeastern margin of Hudson Strait, west of the northern end of Labrador. Five fragments, from different conchs, are numbered 33061, in the U. S. National Museum. From strata regarded as equivalent to the Red River formation, tentatively referred to the Richmond, but possibly of upper Trenton age.

Remarks.—This species certainly is not identical with *Westonoceras ornatum* (Troedsson), described originally as *Thuleoceras ornatum*. From the latter it differs chiefly in size, but also in the greater distance between the septa, in both respects differing from the specimen represented by figures 4 and 5 on plate 55 published by Troedsson, as the holotype of his species, and differing still more from the second specimen represented by the other figures on the same plate.

### 45. **Westonoceras** cf. **manitobense** (Whiteaves)

*Plate LV, figs. 1A, B*

Specimen 58 mm. long. Ventral side not preserved exterior to the siphuncle. The sutures of the septa curve strongly downward laterally, reaching the deepest point of downward curvature apparently a little ventrad of the median line of the lateral sides. The sutures rise evenly, but rather strongly, toward the dorsal side of the conch where they form a broad saddle. The surface of the cast of the interior of the shell is marked by vertical ribs a little more than 1 mm. wide and about 1 mm. distant from each other. Where the conch has a lateral diameter of 15 mm. the siphuncle is at least a distance of 1.5 mm. from the ventral wall of the conch. The diameter of the siphuncle increases from 4 mm. in the fifth segment from the lower end of the specimen to 6 mm. in the twelfth. The corresponding figures for the height of the segments are 3 mm. and 4 mm. The septa curve slightly upward as soon as they come in contact with the connecting rings. At the septal foramen they curve strongly and suddenly backward and form a brim about three quarters as wide as the area of adnation between the connecting rings and the septa. The brim along its entire width is in close contact with the septum and can hardly be separated from the latter. The free part of the connecting rings is almost straight and curves only very slightly outward, along their vertical lateral outlines. This outward curvature of the vertical outlines of the connecting rings appears to become stronger toward the upper part of the specimen, but, unfortunately, the upper three segments of the siphuncle are not preserved.

Occurrence.—Three and a half miles south of Louisiana, Missouri, just under the horizon of the Fernvale; from the Stewartville limestone. No. 83054; in the U. S. National Museum.

Remarks.—The structure of the septal necks of a typical representative of *Westonoceras* suggests the identity of this genus with the genus *Thuleoceras* proposed by Troedsson. The structure of the septal necks of the latter is indicated sufficiently by the clear figures published by Troedsson to leave no doubt as to their identity.

### 46. **Westonoceras** sp.

*Plate LV, fig. 4*

Specimen 25 mm. long. Its dorsoventral diameter increases from 8 mm. at its base to about 18 mm. at its top, the latter diameter being estimated. The cross-section is oval, the ventral part of its outline being more angular. The siphuncle is about 1 mm. from the ventral wall of the conch. The surface of the cast of the interior of the conch is marked by fine vertical striae. The sutures of the septa curve downward laterally, forming rather deep lobes, with their lowest part ventrad of the median line of the lateral sides. Since the specimen apparenty is crushed it can not be determined in what direction the conch is curved; however, the side on which the siphuncle is located appears to be concave. This would give a remarkable difference between this species and typical *Westonoceras;* however, the present specimen is not sufficient to establish this difference beyond all doubt. The siphuncle itself resembles that of typical *Westonoceras.* Apparently there is a recurvature at the septal foramen though the brim can not be very well distinguished. The area of adnation of the connecting rings with the septa is rather narrow and only a little wider than the brim. The width of the segments of the siphuncle does not exceed their length. The free lateral outline of the connecting ring is almost straight vertically.

Occurrence.—Wykoff, Minnesota; from near the top of the section exposed along Prosser Run, from an argillaceous limestone bed which corresponds to the Stewartville dolomite. No. 83056; U. S. National Museum.

*Westonoceras minnesotense* was described by Clarke from the upper half of the Prosser formation at Lime City, in Minnesota. It is cited also from Hader, Stewartsville, Mantorville, and Pleasant Grove in that state. The type has been refigured by Foerste.[30]

### 47. **Westonoceras** (?) **rallsense** Sp. nov.

*Plate XLVII, fig. 4*

Specimen 77 mm. long, and originally about 50 mm. in diameter at midlength. Apparently it enlarges more rapidly at its lower

[30] Foerste, Aug. F., Three Studies of cephalopods, Jour. Sci. Lab., Denison Univ., vol. 24, 1929, p. 312, Westonoceras minnesotense, pl. 48, figs. 3, 4.

end then farther up. Siphuncle very large compared with the diameter of the conch, its diameter equalling 21 mm. where that of the conch is estimated at 50 mm. Its distance from the ventral wall of the conch is estimated here at 17 or 18 mm. Four segments of the siphuncle are preserved, and these have lengths of 14.5 mm., 16.5 mm., 18.5 mm. and 20 mm., when taken in ascending order. Their diameter probably increased in the same direction. The concavity of the septa equals at least 10 mm. Between the segments of the siphuncle their course is almost horizontal, except at the septal foramen where their inner parts curve downward about 1 mm. The septal necks are similar to those of *Westonoceras* and *Elrodoceras* in the strong recurvature of the septa at the septal foramen and the close contact of the brim with the lower side of the septum from which they originate. The immediately overlying and underlying parts of the connecting rings are in contact with the intermediate septa for a width of 5 or 6 mm. The interior of the siphuncle is occupied by actinoceroid calcareous deposits, leaving a central passage or endosiphuncle, now filled with matrix.

Occurrence.—Sanders Fork, Ralls county, in northeastern Missouri; in the Kimmswick limestone. Holotype; no. 82234, U. S. National Museum.

Remarks.—This specimen differs from *Westonoceras* in the large size of its siphuncle compared with the diameter of the conch. From *Elrodoceras* it differs in the location of the siphuncle near the ventral wall of the conch, instead of having a central or subcentral location. It is not certain even that the conch is orthoconic; at least, the lower part of the conch narrows in such a manner as to suggest the possibility of the conch being curved. Therefore there is no certainty of the specimen belonging either to *Westonoceras* or to *Elrodoceras*. We have been guided in referring it to *Westonoceras* solely by the fact that *Westonoceras* is known at present only from strata of Richmond and older age, while *Elrodoceras* is known only from strata of later age than the Richmond. Since the Kimmswick limestone is referred at present to the upper part of the Black River, it, at least, belongs to a lower horizon, at least lower than both the Stewartville and Red River

formations according to its present classification in the geological column. Of course, we are not of the opinion that it is a genuine *Westonoceras*. We here merely desire to call attention to a type of structure somewhat similar to that of *Westonoceras* and *Elrodoceras* in rocks of older age than any from which it formerly was known.

## **ORMOCERAS** Stokes

Genotype: *Ormoceras Bayfieldii* Stokes, Trans. Geol. Soc. London, 2nd ser., vol. 5, 1840, p. 709, pl. 60, fig. 1; Foerste, Contrib. Mus. Geol. Univ. Michigan, vol. 2, 1924, p. 62, text fig. 1; pl. 3, figs. 1A, B.

Typical Ormoceras agrees with *Armenoceras* in the shortness of its septal necks, but the siphuncle is relatively smaller compared with the diameter of the conch, and its segments are not as broadly nummuloidal. Moreover, as a rule, the contractions of the siphuncle at the septal necks are not as deep or narrow as those of typical *Armenoceras*. In typical species the septa are adnate to the inner parts of the lower faces of the overlying connecting rings but are free from contact with the rings below, the entire length of these necks intervening.

In three of the species here described under *Ormoceras*, the septa are in contact with the lower face of the overlying rings only on the ventral side of the siphuncle, but on its dorsal side they are adnate to the upper face of the underlying rings. In this respect they resemble the structure of the siphuncle of *Nybyoceras*, but in the latter genus the siphuncle is so very much larger that it seems inadvisable to refer the three species here mentioned to that genus. Provisionally, therefore, they are referred to *Ormoceras*. The three species are *Ormoceras covingtonense*, *Ormoceras dismukesense*, and *Ormoceras lindsleyi*.

### 48. **Ormoceras cannonense** Sp. nov.

*Plate XLVIII, figs. 3A, B, C; plate LVIII, fig. 7*

Specimen 25 mm. long and enlarging at an apical angle of 10 degrees. At its larger end its lateral diameter is 25 mm., and

from accompanying specimens its dorsoventral diameter is known to have been 1 or 2 mm. shorter, the cross-section of the conch being slightly depressed dorsoventrally. The sutures of the septa are directly transverse or nearly so. The concavity of the upper septa equals 5 mm. The center of the siphuncle is 10 mm. from the ventral wall of the conch, which would place it slightly ventrad of the center of the latter. Where the height of the camerae is about 3 mm. the connecting rings are 2 mm. in height, the length of the septal necks being 0.9 mm.; the diameter of the connecting rings here is 5.2 mm., contracting to 2.3 mm. at the septal necks. The septa are in contact with the lower surface of the connecting rings.

Occurrence.—Nashville, Tennessee; in the *Cyrtodonta* zone of the Cannon member of the Trenton. Holotype; specimen no. 82232; U. S. National Museum.

### 49. **Ormoceras** (?) **covingtonense** Sp. nov.

*Plate XLV, figs. 2A, B; plate LVIII, fig. 9*

Specimen 102 mm. long, enlarging laterally at an angle of 7 degrees. The dorsoventral diameter at the top of the specimen is 30 mm.; the lateral one is estimated at 35 mm. The cross-section apparently was transversely elliptical, with the dorsal and ventral transverse outlines similar. The number of camerae in a length equal to the lateral diameter of the conch is 7. The sutures of the septa are nearly directly transverse; but, from the ventrolateral parts of the conch they slope faintly downward in a dorsad direction, and slightly more distinctly downward ventrally. At the top of the specimen, where its dorsoventral diameter is 30 mm., the concavity of the septa is 7 mm. The center of the siphuncle here is 9 mm. from the ventral wall of the conch. The diameter of the uppermost connecting ring is 9 mm. along its oblique slant, but 8.5 mm. in a directly transverse direction. The height of the camera at this point is 5 mm. In the small diameter of the siphuncle, compared with that of the conch, and also in the small diameter of its segments compared with their height, this siphuncle resembles *Ormoceras*. However, a possible affinity to *Nybyoceras* is indicated by the course of the

septa on the dorsal side of the siphuncle. Here the septa are adnate to the upper surface of the underlying connecting rings for a width of nearly 1.5 mm., while their contact with the lower side of the overlying rings is scarcely one-third as wide. Ventrally, however, the septa are in contact with the lower surface of the overlying rings for a width of 2 mm., while separated from the upper surface of the underlying rings by the very short septal necks, with strongly recurved lower margins, scarcely one-fifth of a millimeter long. All of the preceding measurements were made along the upper part of the specimen.

Occurrence.—Covington, Kentucky; in the Maysville formation. Holotype; specimen no. 48258; U. S. National Museum.

Remarks.—*Ormoceras covingtonense* undoubtedly shows relationship to *Nybyoceras* in the structure of its siphuncle, but it was excluded from the latter on account of the small size of this siphuncle compared with the diameter of the conch. Evidently it indicates a close relationship between the genera *Nybyoceras* and *Ormoceras*. The extreme shortness of its septal necks indicates relationship also with *Armenoceras*. In fact, in the present state of our knowledge it can not be placed in any one of the genera named except in a more or less arbitrary manner.

### 50. **Ormoceras ferecentricum** Sp. nov.

*Plate XLIX, figs. 2A, B; plate LVIII, fig. 10*

Specimen 41 mm. long, enlarging laterally at an apical angle of 7.5 degrees. Cross-section apparently circular. The lateral diameter at the top of the specimen is 34 mm. The number of camerae in a corresponding length is 6. The sutures of the septa slant downward about 1.5 mm. from the dorsal side of the conch to its ventrolateral parts. In case this slant continued as far as the middle of the ventral side of the conch the total descent probably would not exceed 2 mm. The concavity of the septa equals 6.5 mm. The center of the siphuncle is located about 2 mm. ventrad of the center of the conch. At the top of the specimen the connecting rings are 9.5 mm. in diameter and are constricted to 5 mm. at the septal necks. In a vertical direction

these rings are about 4.3 mm. in height, the length of the septal necks being about 1 mm.

Occurrence.—High Bridge, Kentucky, in residual clay over the Tyrone member of the Lowville. Holotype; no. 82214; U. S. National Museum.

### 51. **Ormoceras lindsleyi** Sp. nov.

*Plate LIII, figs. 2A, B, C; plate LIX, fig. 2*

Specimens 53 mm. long, enlarging at an apical angle of 6.5 degrees. At 15 mm. below its top its lateral diameter is 28 mm., and its dorsoventral one is estimated at 26 mm. There are 7.5 camerae in a length corresponding to the lateral diameter of the conch. The sutures of the septa are directly transverse. Their concavity along the upper part of the specimen is at least 4 or 5 mm. The center of the siphuncle is located 2 mm. ventrad of the center of the conch. Where the camerae are 4 mm. in height the segments of the siphuncle are nearly 3.5 mm. wide, and are almost spherical on lateral view. The septal necks are scarcely one-fifth of a millimeter long. The inner part of the septa is in contact for a width of half a millimeter with the upper surface of the underlying connecting ring, while distinctly free from the overlying ring, in a transverse vertical section of the conch, thus suggesting a structure somewhat resembling that of *Nybyoceras*.

Occurrence.—Nashville, Tennessee; in the *Cyrtodonta* zone of the Cannon member of the Trenton. Holotype; U. S. National Museum; no. 82213.

### 52. **Ormoceras normanense** Sp. nov.

*Plate LIII, figs. 3A, B, C; 4; plate LIX, fig. 9*

Specimen differing from *Ormoceras ferecentricum* chiefly in the relatively larger size of its siphuncle and in the closer location of the latter to the ventral wall of the conch.

Specimen 38 mm. long, enlarging from a lateral diameter of 20 mm. at its base to 24 mm. at its top. Five camerae occur in a length of 24 mm. The sutures of the septa are straight but slope slightly downward in a ventrad direction. The concavity

of the septa equals almost the height of one camera. The center of the siphuncle is 7 mm. from the ventral wall of the conch where the diameter of the conch is 20 mm. Here the diameter of the siphuncle is 8 mm. The septal necks are about half a millimeter in length.

Occurrence.—Norman's, Tennessee; in the Tyrone member of the Lowville. Specimen collected by Prof. Safford somewhere in the region surrounding Lebanon, Tennessee, as far as can be judged from the accompanying label. Holotype; U. S. National Museum; no. 82235.

### 53. **Ormoceras troosti** Sp. nov.

*Plate L, figs. 2A, B; plate LIX, fig. 3*

Specimen 113 mm. long, enlarging dorsoventrally from 40 to 44 mm. in a length of 60 mm., indicating an apical angle of 3.5 degrees. The lower 5 camerae occupy a length indicating 6 camerae in a length equal to the dorso-ventral diameter of the conch. Of the overlying camerae, 8 occur in a corresponding length. The sutures of the septa slope strongly downward from the dorsal toward the ventral side of the conch. Where the dorso-ventral diameter of the conch is 44 mm., the center of the siphuncle is 12.5 mm. from the ventral wall of the conch. The connecting rings here are 10.5 mm. in diameter, contracting to 7 mm. at the septal necks, both measurements being parallel to the oblique segments of the siphuncle. The septal necks vary from 1.5 to 2 mm. in length, being distinctly longer ventrally than dorsally. Moreover, along the ventral side of the siphuncle the septa are adnate for a longer distance to the lower part of the connecting rings. The width of the segments of the siphuncle is small compared with the height of the camerae, the latter being about 6 mm. at the level here studied.

Occurrence.—Nashville, Tennessee; in the Catheys member of the Trenton. Holotype; specimen no. 82233; U. S. National Museum.

Remarks.—This species is named in honor of Gerard Troost, the Pioneer State Geologist of Tennessee.

## DEIROCERAS Hyatt

Genotype: *Orthoceras python* Billings, Geol. Surv. Canada, Rep. Progress for 1853–56, published in 1857, p. 335. *Deiroceras python* Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 273.

Conchs with relatively large siphuncles, their segments vertically elongated with elliptical outlines, strongly excentric in location. A fragment of *Deiroceras python* in the Victoria Memorial Museum, at Ottawa, Canada, numbered 1722, consists of three segments of the siphuncle, each about 20 mm. long and 20 mm. in diameter, narrowing approximately to 15 mm. or possibly even a little less at their contact with the septa.

The nearest approach to a type of structure resembling *Deiroceras python*, among figured species, is presented by *Deiroceras remotiseptum*, figured by Hall under the generic name *Ormoceras* from the Black River limestone at Watertown, New York (Hall, 3rd Rep. New York State Cab. Nat. Hist., revised edition, 1850, p. 181, pl. 4, fig. 3). A similar specimen was figured by Clarke under the name *Actinoceras remotiseptum* from the Platteville of Cannon Falls, Minnesota (Geol. Minnesota, vol. 3, pt. 2, 1897, p. 782, pl. 54, figs. 1–3).

Among the species here referred to *Deiroceras* the one named *Deiroceras richteri* shows the closest resemblance to the type. It has proved very difficult to determine in case of some of the other species whether these would not fit in better with *Ormoceras*. However, we assume that in typical *Ormoceras* the location of the siphuncle should be central or subcentral, since this was its location in the genotype *Ormoceras bayfieldi* Stokes. In the species of more doubtful relationship here described, however, the location of the siphuncle was distinctly near the wall of the conch, as in typical *Deiroceras*.

### 54. **Deiroceras python** (Billings)

*Orthoceras python* Billings, Geol. Surv. Canada, Rep. Progress for 1853–56, published in 1857, p. 335.

*Deiroceras python* Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 273.

Since the type of this species has never been figured and the original description is accessible in relatively few libraries, this description here is republished.

Large, elongated, gradually tapering; septa very convex, distant one inch or a little more at the oral extremity, thence becoming more approximate, until at the apex they are scarcely half-an-inch apart; the siphuncle is large and dilated between the septa into a series of sub-globular or oval expansions, decreasing in size from the aperture towards the apex; these are slightly more inflated in the upper than in the lower half. At the apex in one specimen, the most perfect seen, where the septa are five lines distant, the diameter of the last bead of the siphuncle is four lines, and of the twenty-seventh from the apex eleven lines, the length being one inch; the passage through the septa is small. The separated siphuncle of this species is a fossil of a very remarkable appearance, resembling a row of small eggs placed end to end, the size gradually diminishing from the diameter of one inch to that of three or four lines. It is one of these species which will probably not often be found with the septa and external shell preserved, as these portions of the structure appear to have been of a thin and perishable nature, while the siphuncle with the exception of a small central channel (endosiphuncle), was completely solidified by the calcareous secretion of the animal during life, and thus will perhaps be more frequently discovered well preserved. The finest specimen known is a siphon eighteen inches in length, consisting of twenty-seven joints, corresponding to twenty-seven chambers, collected by Mr. P. A. McArthur in the Trenton limestone at the City of Ottawa. In this specimen there are no traces of septa or external shell.

Another specimen consists of a fragment exhibiting on one side eleven of the expansions of the siphuncle, with traces of the septa upon the other. The specimen, although crushed, proves the siphuncle to be considerably excentric, and that the rate of tapering is almost one line to the inch. The eleven joints occupy a length of six and one-fourth inches, and they appear to belong to the terminal half of an individual of medium size. Kenyon township, Ontario.

### 55. **Deiroceras richteri** Sp. nov.

*Plate XLIII, fig. 2; plate LVIII, fig. 5*

Specimen 100 mm. long, cross-section circular, enlarging from a diameter of approximately 40 mm. at its base to 44 mm. at its top. From 2. 3 to 2.5 camerae occur in a length equal to the diameter of the conch. The sutures of the septa appear to slant downward in a ventrad direction. The distance of the siphuncle from the ventral wall of the conch is 2 mm. Its diameter is 13.5 mm. within the camerae, shortening to 8.5 mm. at the septal necks. The latter are from 1 mm. to 1.5 mm. in length. The ventral outline of the connecting rings is distinctly more convex than their dorsal outline, especially along their upper half.

Occurrence.—Sanders Fork, Ralls county, Missouri; in the upper part of the Prosser member of the Trenton. Holotype; specimen no. 82228, in the U. S. National Museum.

This species is named in honor of Dr. Rudolf Richter of Frankfurt on the Main, Germany, in recognition of his eminent services to paleontology.

### 56. **Deiroceras curdsvillense** Sp. nov.

*Plate XLVI, figs. 3A, B; plate LVIII, fig. 6*

Specimen 65 mm. long, enlarging from a dorsoventral diameter of 24 mm. at its base at an angle of 5.5 degrees; cross-section circular. About 3.3 camerae occur in a length equal to the diameter of the conch. The siphuncle is 2 mm. from the ventral wall of the latter. Where the diameter of the conch is 28 mm., that of the siphuncle is 7 mm. within the camerae, contracting to 2.5 mm. at the septal necks. The ventral outline of the connecting rings is distinctly more convex than their dorsal outline, especially along the upper half of the camerae. The length of the septal necks is almost 1 mm.

Occurrence.—Curdsville, Kentucky; in the Curdsville member of the Trenton. Holotype; specimen no. 48221, in the U. S. National Museum.

### 57. **Deiroceras dismukesense** Sp. nov.

*Plate XLIV, figs. 3A, B, C; plate LVIII, fig. 4*

Specimen 23 mm. long, 29 mm. in diameter dorsoventrally, cross-section circular. Rate of enlargement unknown. Four camerae occupy a length suggesting that originally 5 camerae had a total length equal to the diameter of the conch. The sutures of the septa are straight but slope downward moderately in a dorsad direction. The concavity of the septa is 6 mm. The siphuncle is 1 mm. distant from the ventral wall of the conch. Its diameter is 7.5 mm. at midheight within the camerae, constricting to 4 mm. at the septal necks. The structure of these necks can not be determined definitely, but, on the ventral side of the siphuncle, the septa are in contact with the overlying connecting rings for a width of 4 mm., while on its dorsal side they are in contact with the upper surface of the underlying rings for a width of 2 mm., resembling *Nybyoceras* in the latter respect.

Occurrence.—Dismukes, Sumner county, Tennessee; in the Richmond. Holotype; U. S. National Museum, no. 48270.

### 58. **Deiroceras capitolense** Sp. nov.

*Plate XLVI, fig. 2; plate LVIII, fig. 3*

Specimen 120 mm. long, enlarging from a diameter of 27 mm. at its base to 35 mm. at a point 100 mm. farther up. Four camerae occur in a length equal to the diameter of the conch. Where this diameter of the conch is 30 mm., the center of the siphuncle is 7 mm. distant from the ventral wall of the conch. The diameter of the siphuncle here is 7 mm., narrowing to 4.5 mm. at the septal necks. Owing to the strongly excentric location of the siphuncle its segments have a vertically elongate but oblique outline, similar to that of the preceding species described here under the name *Deiroceras*.

Occurrence.—Nashville, Tennessee, on Capitol Hill; from either the Catheys or the Bigby limestone, in the Trenton. U. S. National Museum No. 82243.

### 59. **Deiroceras nashvillense** Sp. nov.

*Plate XLIV, fig. 2; plate LVIII, fig. 8*

Specimen differing from the preceding by its relatively broader siphuncle, its segments being less elongated and more nearly globular in form. Its length is 53 mm., and its diameter is estimated as having increased from about 23 mm. to 27 mm. in a length of 40 mm. Cross-section circular. Three and a quarter camerae occupy a length equal to the diameter of the conch. The concavity of the septa equals the height of one of the camerae. The diameter of the siphuncle varies from 8.8 mm. at its base to 10 mm. at its top. Where the diameter of the conch is 25 mm., the center of the siphuncle is 6.5 mm. from the ventral wall of the conch. The septal necks are slightly over 5 mm. in diameter and scarcely half a millimeter in length, their lower margins curving strongly outward.

Occurrence.—Nashville, Tennessee, on Capitol Hill; from the Catheys limestone. U. S. National Museum No. 82231.

Similar specimens occur in the Catheys one mile north of Fayetteville; also one mile east of Leiper's Fork post-office; and two miles west of Hartsville; all in Tennessee.

## DESCRIPTION OF PLATES

### PLATE XXVII

Fig. 1. *Actinoceras bigsbyi* Bronn. A, ventral view; B, dorsoventral section with ventral outline on right; C, lateral view with ventral outline on left. Beloit, Wisconsin; in the Platteville. No. 15669, U. S. National Museum. See also plate LVI, fig. 2.

Fig. 2. *Actinoceras saffordi* Foerste and Teichert. A, lateral view of fragment, the entire specimen not figured; B, interior view of same fragment with ventral outline on left. Motley's, Tennessee; presumably from the Carters. Holotype; no. 82199, U. S. National Museum. See also plate LVII, fig. 4.

1A

1B

1C

2A

2B

## PLATE XXVIII

Fig. 1. *Actinoceras tenuifilum* (Hall). Dorsal view; basal part of specimen sectioned so as to expose the siphuncle. Watertown, New York; in the Watertown member of the Black River. Lectotype; no. 12242-1, in the New York State Museum. Same specimen as that represented by fig. 1 on plate 15, Pal. New York, vol. 1, 1847. The basal part is shown also by fig. 4 on plate XXXIX of the present publication. The total length of the specimen is 205 mm.

Fig. 2. *Actinoceras beloitense* (Whitfield). Ventral view of conch showing the tapering of the living chamber toward its aperture. St. Joseph island, in the northwestern part of Lake Huron; in the Black River limestone. Much reduced in size, the part figured being 450 mm. long. The upper part of the phragmacone of this specimen is represented by fig. 1 on plate XXIX. A vertical dorsoventral section of another specimen from the same locality is shown by figs. 1A, B on plate XXX. No. 82226, U. S. National Museum.

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## PLATE XXIX

Fig. 1. *Actinoceras beloitense* (Whitfield). Ventral view of the upper part of the phragmacone of the same specimen as that illustrated on plate XXVIII. The part here figured is 223 mm. long. St. Joseph island, Lake Huron; in the Black River. No. 82226, U. S. National Museum.

1

## PLATE XXX

Fig. 1. *Actinoceras beloitense* (Whitfield). A, B, a continuous dorsoventral section including the lower 300 mm. of a phragmacone 340 mm. long, the total length of the conch, including the living chamber, being 485 mm. Its ventral outline is on the right. No. 82225, U. S. National Museum. See also plate LIX, figs. 1A, B.

Fig. 2. *Actinoceras cf. saffordi* Foerste and Teichert. Fragment of conch showing dorsal side of siphuncle. Franklin, Tennessee; in the Carters. No. 82201, U. S. National Museum.

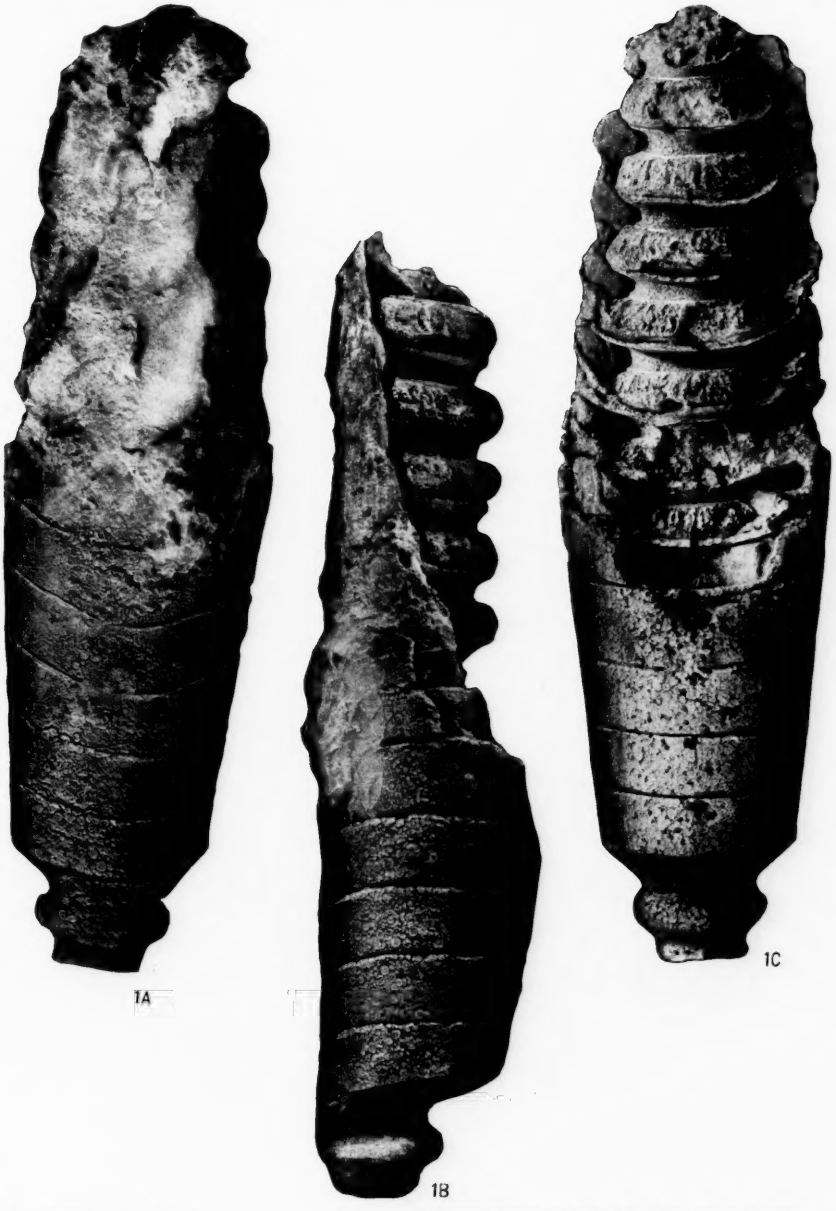
1A

2

1B

## PLATE XXXI

Fig. 1. *Actinoceras glenni* Foerste and Teichert. A, Ventral view; B, lateral view with ventral outline on left; C, dorsal view showing dorsal side of siphuncle. Note apical end of specimen, differing from that of *Kochoceras*. Nashville, Tennessee; possibly from the Tyrone. Holotype; no. 82207, U. S. National Museum. See also plate LVI, fig. 10.



1A 1B 1C

## PLATE XXXII

Fig. 1. *Actinoceras kentuckiense* Foerste and Teichert. A, ventral view; B, lateral view with ventral outline on left. High Bridge, Kentucky; in the Tyrone. Holotype; no. 82237, U. S. National Museum. See also pl. XXXIII, fig. 1, for dorsoventral section through the siphuncle. For cross-section see plate LVII, fig. 3.

1A 1B

## PLATE XXXIII

Fig. 1. *Actinoceras kentuckiense* Foerste and Teichert. Dorsoventral section through siphuncle with ventral outline on right. High Bridge, Kentucky; in the Tyrone. See also plate XXXII for other views of same specimen. Holotype; no. 82237, U. S. National Museum. For cross-section see plate LVII, fig. 3.

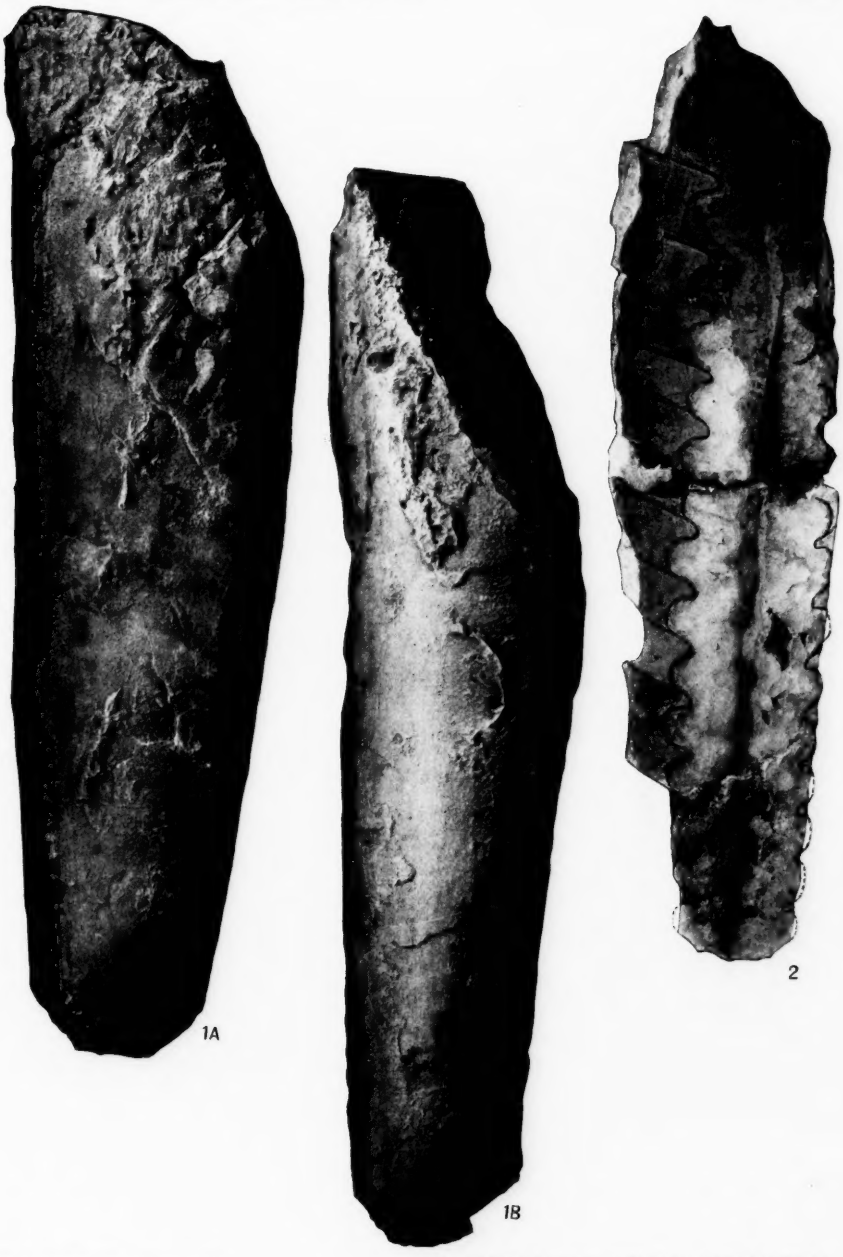
Fig. 2. *Actinoceras* (?) *lindenense* Foerste and Teichert. Specimen weathered away dorsally so as to expose the siphuncle, the latter contracting toward the top. Linden Hall, Center county, Pennsylvania. Holotype; no. 82229, U. S. National Museum.

1 2

## PLATE XXXIV

Fig. 1. *Actinoceras libanum* Foerste and Teichert. A, ventral view; B, lateral view with ventral side on left. High Bridge, Kentucky; in the Lebanon division of the Camp Nelson formation. One of the cotypes, numbered 48424 B in the U. S. National Museum. See also plate LVII, fig. 5.

Fig. 2. *Actinoceras libanum* Foerste and Teichert. Dorsoventral section through the siphuncle of another specimen. High Bridge, Kentucky; in the Lebanon member of the Camp Nelson formation. The other cotype, numbered 48424A, in the U. S. National Museum.


1A
1B
2

## PLATE XXXV

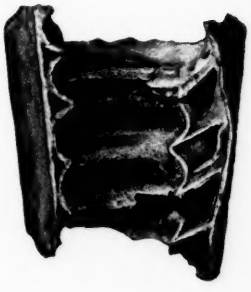
Fig. 1. *Actinoceras altopontense* Foerste and Teichert. A, ventral view, showing contact areas between the siphuncle and the ventral wall of the conch; B, same specimen weathered so as to show the dorsal side of the siphuncle; C, lateral, view, with ventral outline on right. High Bridge, Kentucky; in the Tyrone. Holotype; no. 82196, U. S. National Museum. See also plate LVI, fig. 1.

Fig. 2. *Actinoceras tennesseense* Foerste and Teichert. A, lateral view of interior, with ventral outline on left; B, lateral view of exterior with ventral outline on left. Motley's, Tennessee; apparently from the Carters. Holotype; no. 82202, U. S. National Museum. See also plate LIX, fig. 8.

1A

1B

1C



2A

2B

## PLATE XXXVI

Fig. 1. *Actinoceras centrale* Foerste. Transverse section in a lateral direction of the type specimen, of which only the upper half was published on plate XXX of volume 19 of this Journal in 1921. Watertown, New York; in the Watertown member of the Black River. Holotype; no. 78483, U. S. National Museum. See also plate LVI, fig. 6.

Fig. 2. *Actinoceras lentiexpandum* Foerste and Teichert. Dorsoventral section of conch through the siphuncle, with ventral outline on left. Central Tennessee, exact locality unknown; in lower part of the Cannon limestone. Holotype; no. 82211, U. S. National Museum. See also plate LVII, fig. 1.

1

2

## PLATE XXXVII

Fig. 1. *Actinoceras caneyense* Foerste and Teichert. A, ventral view; B, dorsoventral section of conch through the siphuncle, with ventral outline on right. Caney Fork, DeKalb county, Tennessee; either from the Cannon, or possibly from the basal Tyrone. Holotype; no. 82194, U. S. National Museum. See also plate LVI, fig. 7.

Fig. 2. *Actinoceras pohli* Foerste and Teichert. A, lateral view with ventral outline on right; B, view of interior showing the siphuncle, with ventral outline on left; C, same, viewed from above, with ventral outline on left. Middle Tennessee, exact locality unknown; presumably from the Carters. Holotype; no. 82205, U. S. National Museum. See also plate LVII, fig. 8.

1A

1B

2C

2A

2B

## PLATE XXXVIII

Fig. 1. *Actinoceras jessaminense* Foerste and Teichert. A, lateral view with ventral outline on left; B, lateral view showing part of the siphuncle at its base, with ventral outline on right. High Bridge, Kentucky; in the Tyrone. Holotype; no. 82198, U. S. National Museum. See also plate LVII, fig. 2.

Fig. 2. *Actinoceras bellefontense* Foerste and Teichert. A, lateral view with ventral outline on left; B, dorsoventral section of conch through the siphuncle, with ventral outline on right. Bellefonte, Pennsylvania; in basal part of Lowville. Holotype; no. 82204, U. S. National Museum. See also plate LVI, fig. 4.

Fig. 3. *Actinoceras paquettense* Foerste and Teichert. A, conch weathered so as to expose the dorsal side of the siphuncle; B, lateral view of same with dorsal outline of siphuncle on right; C, ventral view of another specimen, showing lenticular areas of contact between segments of siphuncle and ventral wall of conch. Paquette Rapids, on Ottawa River, 70 miles northwest of Ottawa, Canada; in Leray member of the Lowville. Cotypes; no. 6294, Victoria Memorial Museum. See also plate LVII, fig. 6.

1A
1B
3A
3C
2A
2B
3B

## PLATE XXXIX

Fig. 1. *Actinoceras arcanum* Foerste and Teichert. A, view of interior of conch exposing dorsal side of siphuncle; B, ventral view, showing lenticular areas of contact between the segments of the siphuncle and the ventral wall of the conch. High Bridge, Kentucky; in the Tyrone. Holotype; no. 82238, U. S. National Museum. See also plate LVI, fig. 3.

Fig. 2. *Actinoceras curdsvillense* Foerste and Teichert. A, ventral view of fragment of conch; B, dorsal side of same exposing the lateral outlines of the siphuncle. Curdsville, Kentucky; Holotype; no. 48425, U. S. National Museum. See also plate LVI, fig. 9.

Fig. 3. *Actinoceras adnatum* Foerste and Teichert. A, dorsal side of siphuncle; B, lateral view with ventral outline on right; C, ventral view showing continuous lenticular areas of contact between the siphuncle andthe ventral wall of the conch. Glencoe, Missouri; in the upper part of the Plattin. Holotype; no. 82191, U. S. National Museum.

Fig. 4. *Actinoceras tenuifilum* (Hall). Section through the conch in a somewhat obliquely lateral direction through the siphuncle. Watertown, New York; in the Watertown member of the Black River. Basal part of the lectotype; no. 12242-1, New York State Museum. Magnified 1.2 diameters. See also plate XXVIII, fig. 1.

1A

1B

3A

2A

2B

3B

3C

4

## PLATE XL

Fig. 1. *Actinoceras circulare* Foerste and Teichert. A, ventral view; B, lateral view of same fragment, exposing the siphuncle. Glencoe, Missouri; in the upper Plattin. Holotype; no. 82208, U. S. National Museum. See also plate LVI, fig. 8.

Fig. 2. *Actinoceras glencoense* Foerste and Teichert. A, dorsal view, exposing the siphuncle; B, ventral view showing lenticular areas of contact between the siphuncle and the ventral wall of the conch; C, lateral view, with ventral outline on left. Glencoe, Missouri; in the upper Plattin. Holotype; no. 82197A, U. S. National Museum. See also plate LVI, fig. 11.

Fig. 3. *Actinoceras bigsbyi* Bronn. Lateral view with ventral outline on left, exposing part of the siphuncle. Beloit, Wisconsin; in the Platteville. No. 82192, U. S. National Museum. See also plate 27, figs. 1A, B, C, for views of another specimen from the same locality. For cross-section see plate LIX, fig. 6.

1A

1B

2A

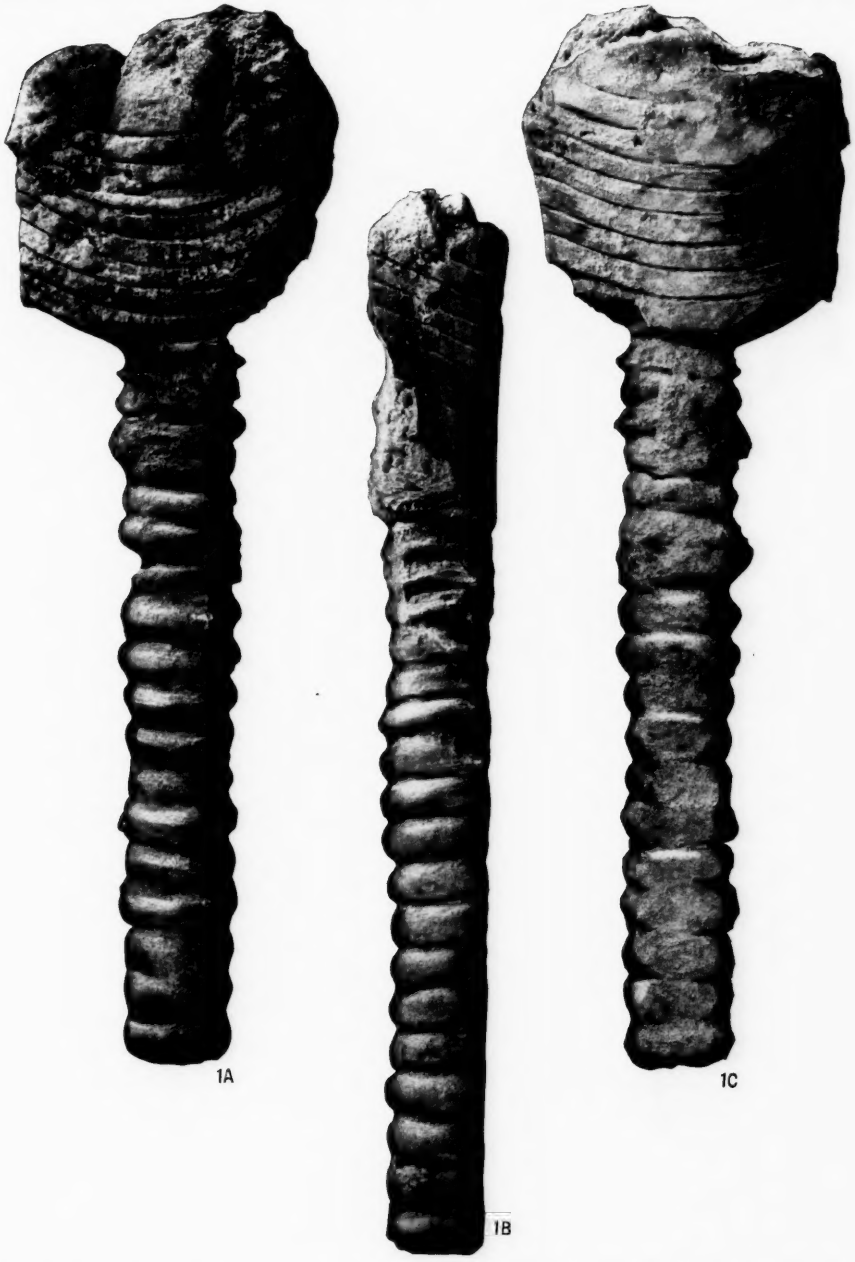
3

2B

2C

## PLATE XLI

Fig. 1. *Actinoceras capitolinum* (Safford). A, dorsal side of specimen; B, lateral view with ventral outline on right; C, ventral view. Nashville, Tennessee; in the Bigby. Holotype; no. 48426, U. S. National Museum. See also plate LVII, fig. 7.



1A 1B 1C

## PLATE XLII

Fig. 1. *Leurorthoceras lebanonense* Foerste and Teichert. A, lateral view with ventral outline on right; B, dorsoventral section with ventral outline on left. Lebanon, Tennessee; in the Lebanon. Holotype; no. 82223, U. S. National Museum. See also plate LIX, fig. 1.

Fig. 2. *Leurorthoceras altopontense* Foerste and Teichert. Dorsoventral section, with ventral outline on left. High Bridge, Kentucky; in the Lebanon member of the Camp Nelson formation. Holotype; no. 82212, U. S. National Museum.

2

1B

1A

## PLATE XLIII

Fig. 1. *Armenoceras richardsoni* (Stokes). A, dorsoventral section with ventral outline on left; B, inner end of septum at the septal neck, magnified 12 diameters, to show the abruptly reflected brim. Lower Fort Garry, Manitoba, Canada; in the Selkirk member of the Red River formation. Specimen no. 4761A, B; U. S. National Museum.

Fig. 2. *Deiroceras richteri* Foerste and Teichert. Dorsoventral section with ventral outline on left. Sanders Fork, Ralls county, Missouri; in the upper Prosser. Holotype; no. 82228, U. S. National Museum. See also plate LVIII, fig. 5.

1B

2

1A

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## PLATE XLIV

Fig. 1. *Armenoceras brevicameratum* Foerste and Teichert. A, lateral view with ventral outline on right; B, dorsoventral section with ventral outline on right. Nashville, Tennessee; in the Catheys. Holotype; no. 82222, U. S. National Museum. See also plate LVIII, fig. 2.

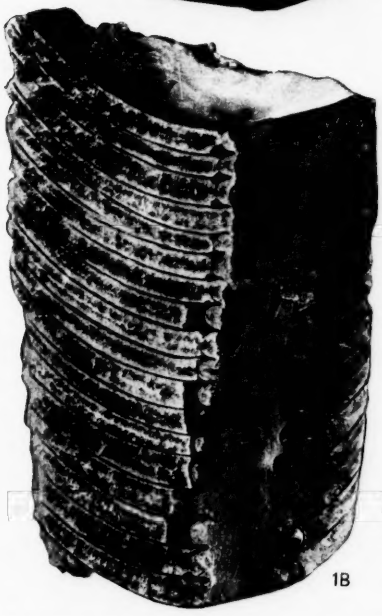
Fig. 2. *Deiroceras nashvillense* Foerste and Teichert. Dorsoventral section with ventral outline on left. Nashville, Tennessee; in the Catheys. Holotype; no. 82231, U. S. National Museum. See also plate LVIII, fig. 8.

Fig. 3. *Deiroceras dismukesense* Foerste and Teichert. A, lateral view with ventral outline on left; B, ventral view; C, dorsoventral section with ventral outline on right. Dismukes, Tennessee; in the Richmond. Holotype; no. 48270, U. S. National Museum. See also plate LVIII, fig. 4.

1A

2

3A



1B

3B

3C

## PLATE XLV

Fig. 1. *Armenoceras madisonense* Foerste and Teichert. A, dorsal side of specimen showing the siphuncle; B, dorsoventral section through top of same, exposing the siphuncle; C, section through septal neck of siphuncle magnified 12 diameters, and showing the strongly reflected brim of the latter. Holotype; no. 15493, U. S. National Museum. See also plate LVIII, fig. 1.

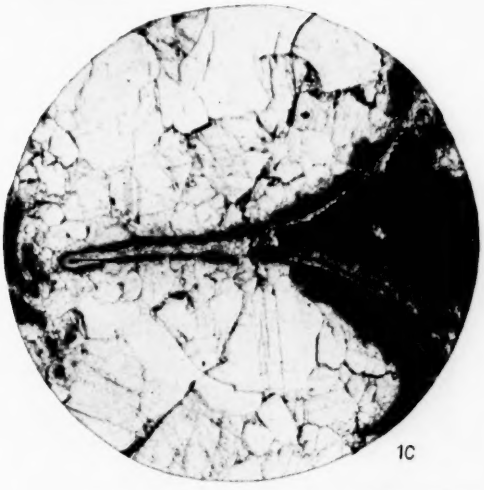
Fig. 2. *Ormoceras* (?) *covingtonense* Foerste and Teichert. A, lateral view with ventral outline on left; B, dorsoventral section with ventral outline on right. Covington, Kentucky; in the Maysville. Holotype; no. 48258, U. S. National Museum. See also plate XLV, fig. 9.

1A

2A

2B

1B



1C

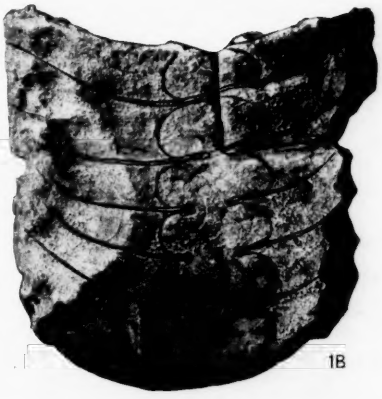
## PLATE XLVI

Fig. 1. *Nybyoceras ulrichi* Foerste and Teichert. A, lateral view, with ventral side on right; B, ventral side weathered so as to show the siphuncle; C, dorsoventral section through the siphuncle, magnified 1.5 diameters, showing the abruptly reflected brim of the septal neck, and the contact between the septum and the upper face of the underlying connecting ring. North of Springer, Carter county, Oklahoma; in the Simpson group. Holotype; no. 82227, U. S. National Museum.

Fig. 2. *Deiroceras capitolense* Foerste and Teichert. Ventral side of conch weathered so as to expose the siphuncle. Nashville, Tennessee; in the Catheys or possibly the Bigby limestone. Holotype; no. 82243, U. S. National Museum. See also plate LVIII, fig. 3.

Fig. 3. *Deiroceras curdsvillense* Foerste and Teichert. A, lateral view with ventral outline on left; B, dorsoventral section with ventral outline on left. Curdsville, Kentucky; in the Curdsville member of the Trenton. Holotype; no. 48221, U. S. National Museum. See also plate LVIII, fig. 6.

1A



1B

2

1C

3A

3B

## PLATE XLVII

Fig. 1. *Elrodoceras indianense* (Miller). Section through the septal neck, showing the strongly reflected brim and the contact of the septum with the upper face of the underlying connecting ring. St. Paul, Indiana; in the Laurel member of the Niagaran. Specimen no. 82240 C, cut from 82240 B; U. S. National Museum. (Magnified 12 diameters.)

Fig. 2. *Elrodoceras telleri* Foerste and Teichert. Ventral side of specimen weathered so as to expose the siphuncle with traces of the endosiphuncle with its radiating tubuli. Racine, Wisconsin; in the Racine member of the Niagaran. Holotype; no 82239, U. S. National Museum. See also plate LVIII, fig. 12.

Fig. 3. *Elrodoceras osmanense* Foerste and Teichert. Lateral section showing the structure of the siphuncle. East of West Union, Ohio; in the Dayton limestone member of the Clinton. Holotype, no. 81920, U. S. National Museum.

Fig. 4. *Westonoceras* (?) *rallsense* Foerste and Teichert. Section in a lateral direction, showing the structure of the siphuncle. Sanders Fork, Ralls county, Missouri; in the Kimmswick. Holotype; no. 82234, U. S. National Museum.

1

2

3

4

## PLATE XLVIII

Fig. 1. *Rayonnoceras vaughanianum* (Girty). Dorsoventral section with ventral side on left, showing the structure of the siphuncle. Hill on east side of Oil Spring crossing of Hickory creek, in Washita mountain area, Oklahoma; from boulders of Mississippian age included in the Caney shale. Specimen no. 82217, U. S. National Museum.

Fig. 2. *Rayonnoceras buffaloense* Foerste and Teichert. A, dorsoventral section with ventral outline on left; B, dorsal view of conch. Near west end of Buffalo mountain, Oklahoma; in boulder of Mississippian age in the Caney shale. Holotype; no. 82220, U. S. National Museum.

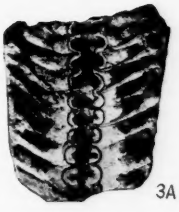
Fig. 3. *Ormoceras cannonense* Foerste and Teichert. A, specimen weathered so as to expose the siphuncle; B, exterior of another specimen; C, a third specimen, also weathered so as to show the siphuncle. Nashville, Tennessee; in the Cannon member of the Trenton. Specimens numbered 82232 in the U. S. National Museum. Of these the one represented by figure 3A is the holotype. See also plate LVIII, fig. 7.

1

2A

2B

3C



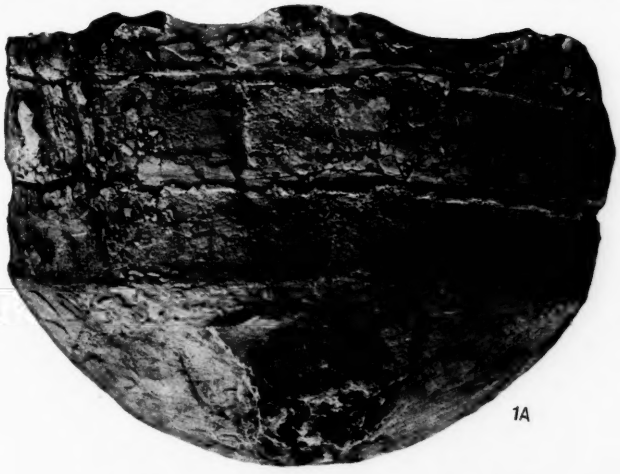
3A

3B

## PLATE XLIX

Fig. 1. *Rayonnoceras girtyi* Foerste and Teichert. A, exterior of specimen; B, opposite side showing the siphuncle. From Oklahoma; probably from the Washita mountain area; from a boulder of Mississippian age in the Caney shale. Holotype; no. 82221, U. S. National Museum. See also pl. L, fig. 1.

Fig. 2. *Ormoceras ferecentricum* Foerste and Teichert. A, exterior of specimen; B, weathered side of same showing the siphuncle. High Bridge, Kentucky; in the residual layer over the Tyrone. Holotype; no. 82214, U. S. National Museum. Plate LVIII, fig. 10.



1A

1B

2A

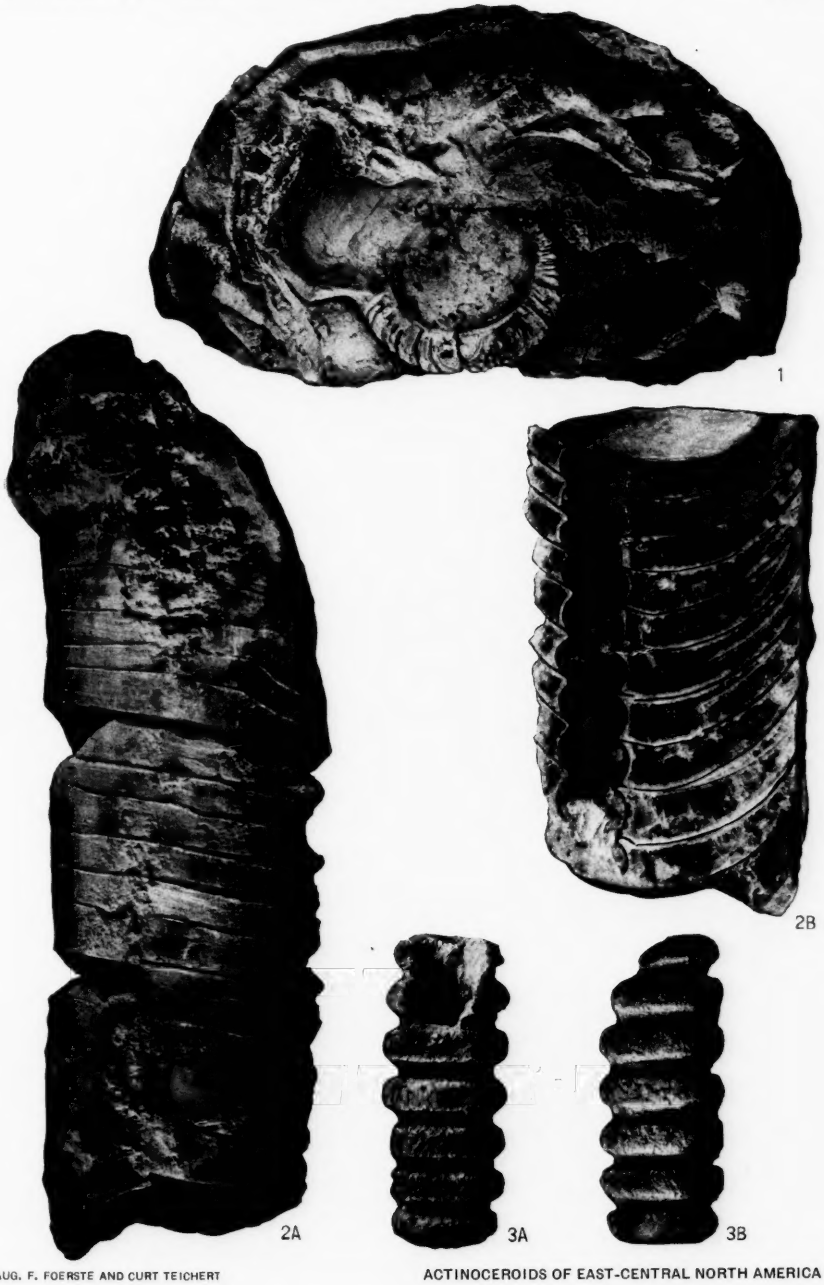
2B

## PLATE L

Fig. 1. *Rayonnoceras girtyi* Foerste and Teichert. Same specimen as that represented by figures 1A, B, on plate XLIX, viewed from its lower side, showing the location of the siphuncle, from Oklahoma, probably from the Washita mountain area; from a boulder of Mississippian age in the Caney shale, Holotype; no. 82221, U. S. National Museum.

Fig. 2. *Ormoceras troosti* Foerste and Teichert. A, lateral view with ventral outline on right; B, dorsoventral section with ventral outline on left. Nashville, Tennessee; in the Catheys. Holotype; no. 82233, U. S. National Museum. See also plate LIX, fig. 3.

Fig. 3. *Actinoceras cinctum* Foerste and Teichert. A, dorsal side of siphuncle; B, lateral view. Glencoe, Missouri; in the upper Plattin. Holotype; no 82195, U. S. National Museum.

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## PLATE LI

Fig. 1. *Rayonnoceras cf. vaughanianum* (Girty). Specimen weathered so as to show the siphuncle. Presumably from some locality in Oklahoma, from some Mississippian boulder in the Caney shale, but exact origin unknown. Specimen no. 82219, U. S. National Museum.

1

## PLATE LII

Fig. 1. *Rayonnoceras bassleri* Foerste and Teichert. A, B, two parts of a continuous dorsoventral section, with ventral outline on right, its total length being 220 mm. From some unknown locality, possibly from the Fayetteville shale of Arkansas. Holotype; no. 82216, U. S. National Museum. See also plate LIX, fig. 4.

Fig. 2. *Actinoceras ruedemanni* Foerste and Teichert. Dorsoventral section with ventral outline on right. Watertown, New York; in the Watertown member of the Black River. Holotype; no. 82215, U. S. National Museum. See also plate LVII, fig. 9.

1A

1B

2

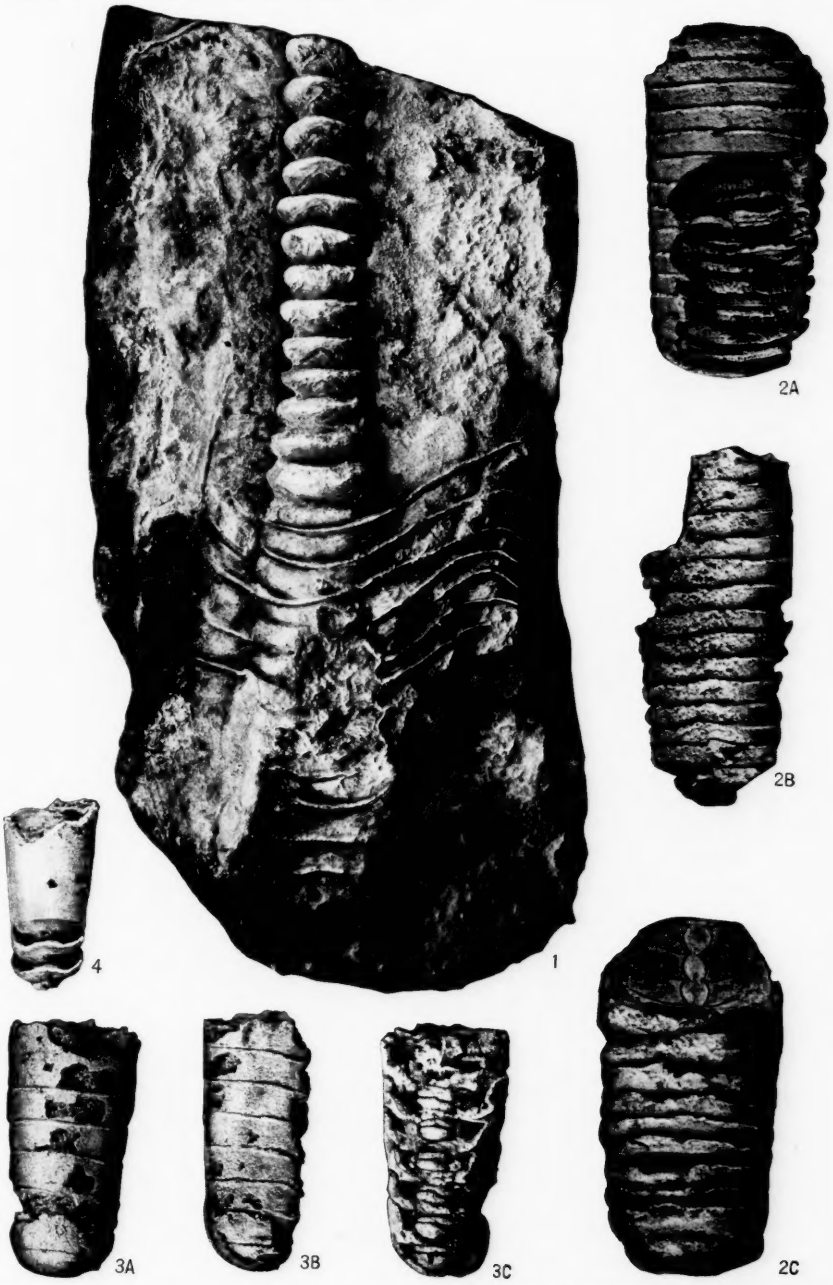
## PLATE LIII

Fig. 1. *Saffordoceras nelsoni* Foerste and Teichert. Ventral side of conch weathered so as to show the siphuncle, the latter contracting toward the top. Nashville, Tennessee; in the Catheys. Holotype; no. 82224, U. S. National Museum. Closely similar to Safford's fig. 1c, on his plate 4, of the Geology of Tennessee, 1869.

Fig. 2. *Ormoceras lindsleyi* Foerste and Teichert. A, dorsal view; B, lateral view; C, ventral view, showing siphuncle at top. Nashville, Tennessee; in the Cannon member of the Trenton. Holotype; no. 82213, U. S. National Museum. See also plate LIX, fig. 2.

Fig. 3. *Ormoceras normanense* Foerste and Teichert. A, dorsal view; B, lateral view; C, ventral side weathered so as to show the siphuncle. Norman's, Tennessee; in the Tyrone. Holotype; no. 82235, U. S. National Museum. See also plate LIX, fig. 9.

Fig. 4. *Ormoceras normanense* Foerste and Teichert. A smaller specimen apparently belonging to the same species. From the same locality and horizon as the preceding.

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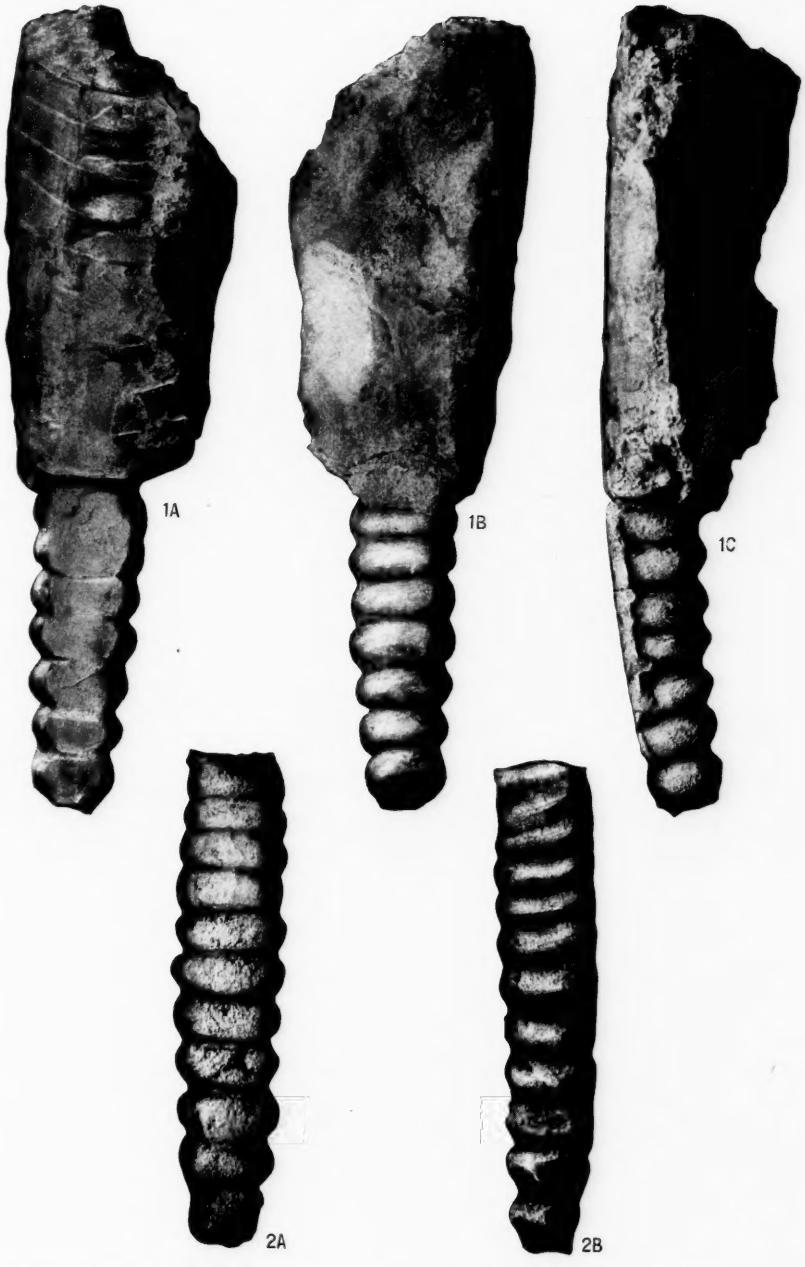
## PLATE LIV

Fig. 1. *Troostoceras paulocurvatum* Foerste and Teichert. A, ventral view; B, dorsal view; C, lateral view, with ventral outline on left. Nashville, Tennessee; in the Bigby member of the Trenton. Holotype; no. 83053, U. S. National Museum. See also plate LIX, fig. 5.

Fig. 2. *Troostoceras paulocurvatum abbreviatum* Foerste and Teichert. A, ventral view showing flattening of siphuncle where in contact with ventral wall of conch; B, lateral view of siphuncle with ventral outline on right. Probably from vicinity of Nashville, Tennessee; in the Bigby member of the Trenton. Holotype; no. 82230, U. S. National Museum.




AUG. F. FOERSTE AND CURT TEICHERT ACTINOCEROIDS OF EAST-CENTRAL NORTH AMERICA

## PLATE LV

Fig. 1. *Westonoceras cf. manitobense* (Whiteaves). A, dorsal view; B, lateral section across ventral side of conch, showing structure of siphuncle. Three and a half miles south of Louisiana, Missouri; from the Stewartville, just under the Fernvale horizon of the Richmond. Specimen no. 83054, U. S. National Museum.

Fig. 2. *Westonoceras iowense* Foerste and Teichert. A, lateral view, with ventral outline on right; B, dorsoventral section of part of same magnified 3 diameters. Near mouth of creek 2 miles northwest of Clermont, Iowa; from the Stewartville, just under the Clermont member of the Maquoketa. Holotype; no. 83055, U. S. National Museum.

Fig. 3. *Westonoceras cf. iowense* Foerste and Teichert. A, lateral view; B, lateral view of another specimen; C, section in a lateral direction across ventral side of specimen exposing one side of siphuncle, magnified 2 diameters. Several specimens from a series found on Akpatok Island, in Hudson Strait; presumably from strata equivalent to some part of the Red River formation. Numbered 33061, in the U. S. National Museum.

Fig. 4. *Westonoceras sp.* Lateral view of specimen, apparently with siphuncle located on concave side of conch. Wykoff, Minnesota; from strata corresponding to the Stewartville dolomite. No. 83056, U. S. National Museum.

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3A

2A

1B

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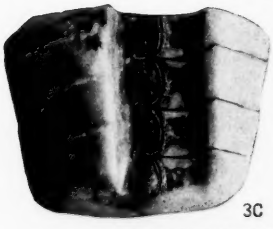

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## PLATE LVI

Fig. 1. *Actinoceras altopontense.* Cross-section of conch, showing also maximum diameter of connecting ring and minimum diameter of septal neck at same level. See also plate XXXV, figs. 1A, B, C.

Fig. 2. *Actinoceras bigsbyi.* Cross-section of same specimen as plate XXVII, figs. 1A, B, C. See also plate LIX, fig. 6.

Fig. 3. *Actinoceras arcanum.* Cross-section of same specimen as plate XXXIX, figs. 1A, B.

Fig. 4. *Actinoceras bellefontense.* Cross-section of same specimen as plate XXXVIII, figs. 2A, B.

Fig. 5. *Actinoceras bigsbyi.* Cross-section of Bigsby's fig. 1 (No. 33448, British Museum of Natural History), copied by Foerste in Contrib. Mus. Geol. Univ. Michigan, vol. 2, pl. 1, as figs. 1A, B, in 1924.

Fig. 6. *Actinoceras centrale.* Cross-section of same specimen as plate XXXVI, fig. 1.

Fig. 7. *Actinoceras caneyense.* Cross-section of same specimen as plate XXXVII, figs. 1A, B

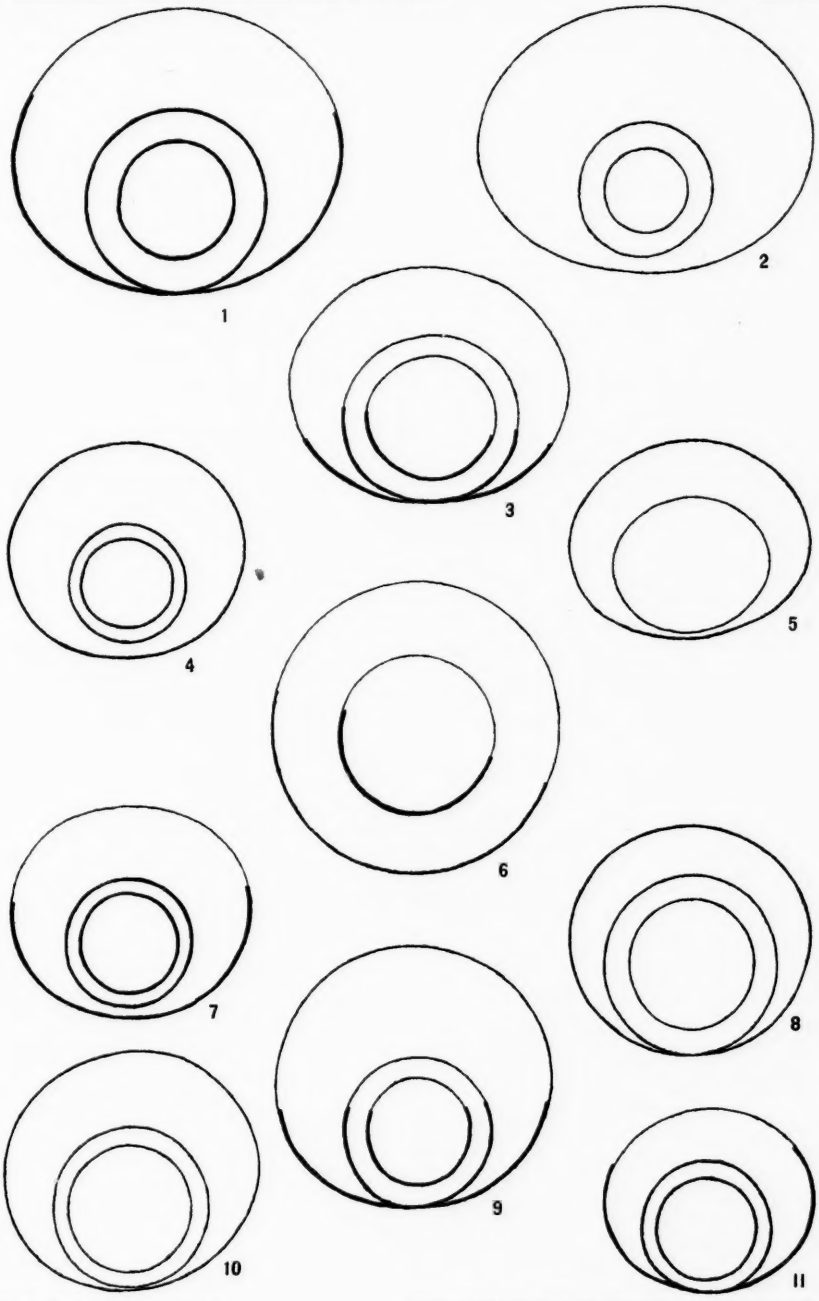
Fig. 8. *Actinoceras circulare.* Cross-section of same specimen as plate XL, figs. 1A, B.

Fig. 9. *Actinoceras curdsvillense.* Cross-section of same specimen as plate XXXIX, figs. 2A, B.

Fig. 10. *Actinoceras glenni.* Cross-section of same specimen as plate XXXI, figs. 1A, B, C.

Fig. 11. *Actinoceras glencoense.* Cross-section of same specimen as plate XL, figs. 2A, B, C.

In cross-section of conchs which are imperfect, usually owing to weathering, the missing parts are indicated by the narrower width of the lines. However, in cross-sections with no parts missing no part of any line is conspicuously darkened.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## PLATE LVII

Fig. 1. *Actinoceras lentiexpandum.* Cross-section of same specimen as plate XXXVI, fig. 2.

Fig. 2. *Actinoceras jessaminense.* Cross-section of same specimen as plate XXXVIII, figs. 1A, B.

Fig. 3. *Actinoceras kentuckiense.* Cross-section of same specimen as plate XXXII, figs. 1A, B; plate XXXIII, fig. 1.

Fig. 4. *Actinoceras saffordi.* Cross-section of same specimen as plate XXVII, figs. 2A, B.

Fig. 5. *Actinoceras libanum.* Cross-section of same specimen as plate XXXIV, fig. 2.

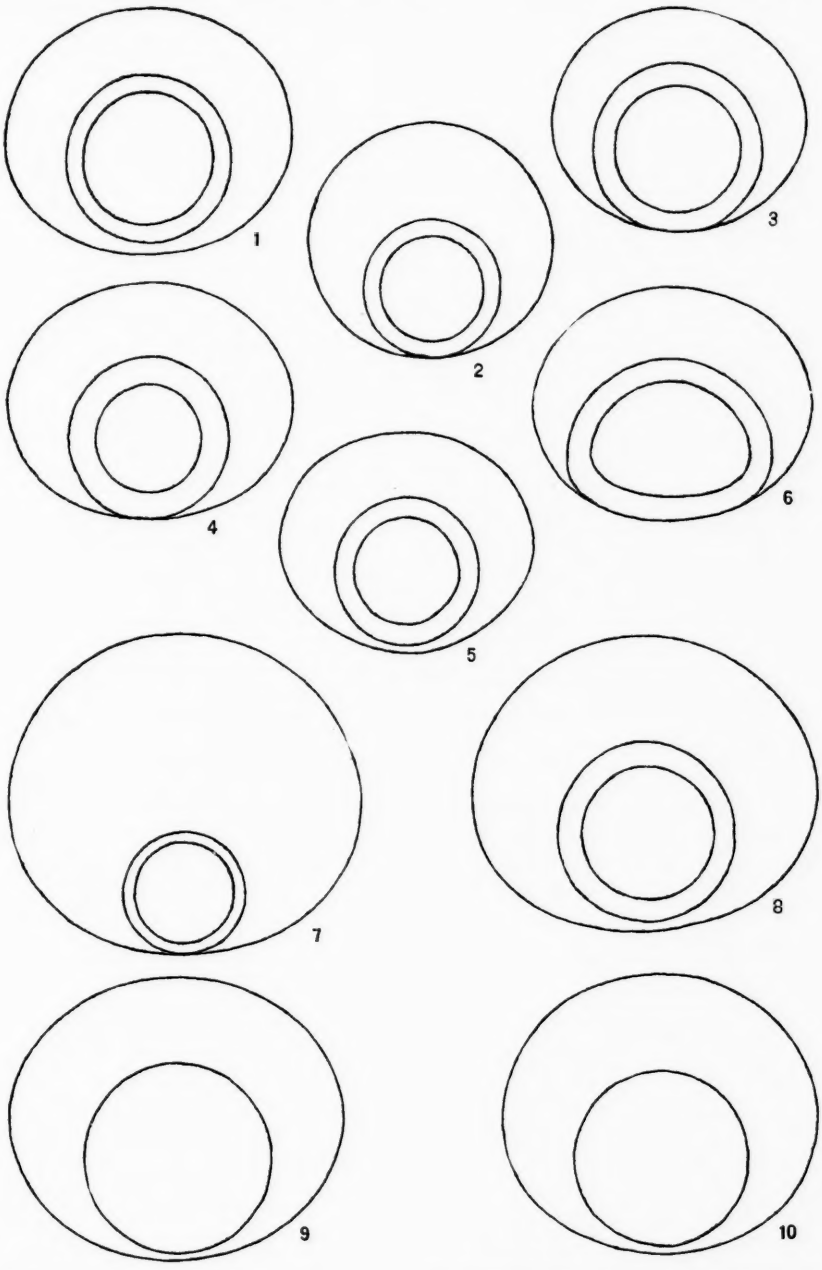
Fig. 6. *Actinoceras paquettense.* Cross-section of same specimen as plate XXXVIII, figs 3A, B.

Fig. 7. *Actinoceras capitolinum.* Cross-section of same specimen as plate XLI, figs. 1A, B, C; however, only the ventral side is preserved, and the dorsal outline may be different. See section published by Safford in Geology of Tennessee, 1869, pl. 4, fig. 1B.

Fig. 8. *Actinoceras pohli.* Cross-section of same specimen as plate XXXVII, figs. 2A, B, C.

Fig. 9. *Actinoceras ruedemanni.* Cross-section based on specimens 82215 and 34019 in the U. S. National Museum, the former being represented on plate LII, by fig. 2.

Fig. 10. *Actinoceras tenuifilum.* Cross-section of the lectotype, represented on plate XXVIII by fig. 1, and on plate XXXIX by fig. 4.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## PLATE LVIII

Fig. 1. *Armenoceras madisonense.* Cross-section of same specimen as plate XLV, figs. 1A, B, C.

Fig. 2. *Armenoceras brevicameratum.* Cross-section of same specimen as plate XLIV, figs. 1A, B.

Fig. 3. *Deiroceras capitolense.* Cross-section of same specimen as plate XLVI, fig. 2.

Fig. 4. *Deiroceras dismukesense.* Cross-section of same specimen as plate XLIV, figs. 3A, B, C.

Fig. 5. *Deiroceras richteri.* Cross-section of same specimen as plate XLIII, fig. 2.

Fig. 6. *Deiroceras curdsvillense.* Cross-section of same specimen as plate XLVI, figs. 3A, B.

Fig. 7. *Ormoceras cannonense.* Cross-section of same specimen as plate XLVIII, figs. 3A.

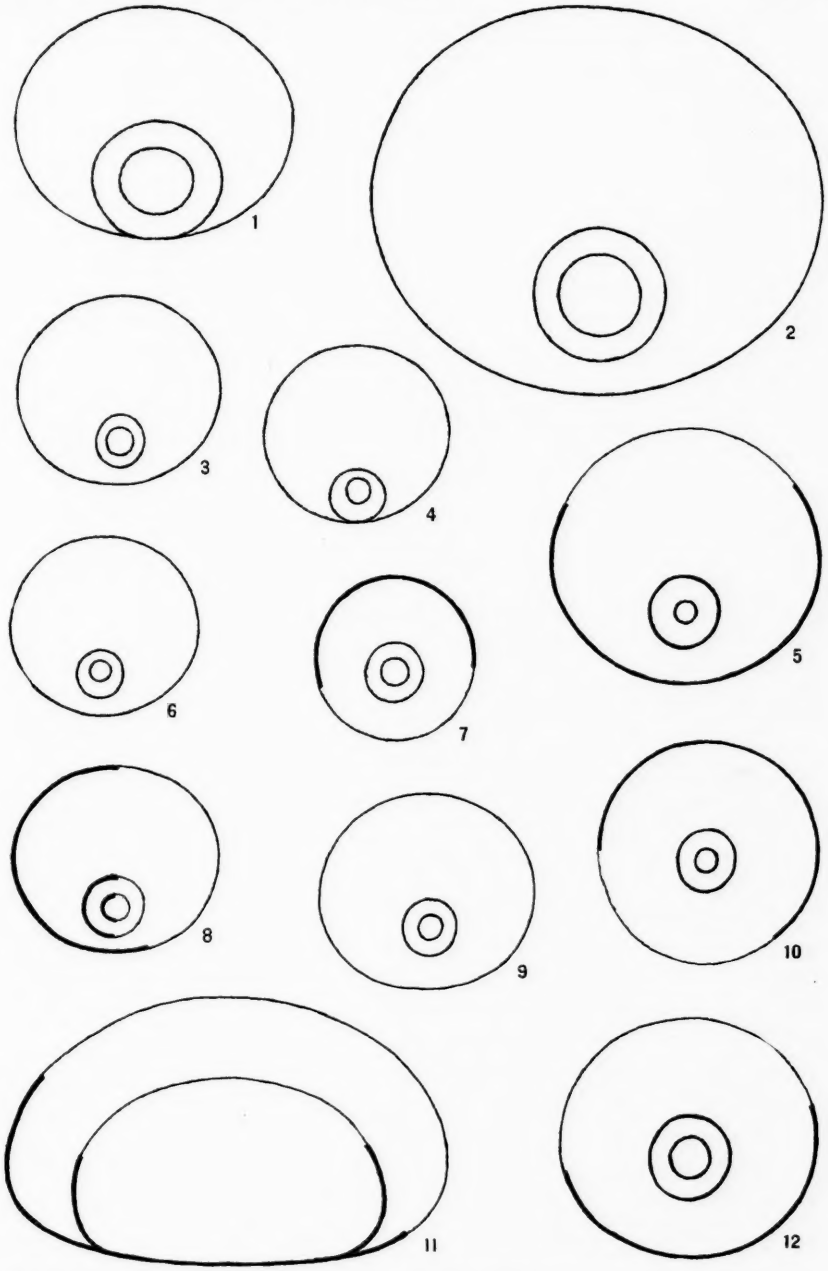
Fig. 8. *Deiroceras nashvillense.* Cross-section of same specimen as plate XLIV, fig. 2.

Fig. 9. *Ormoceras* (?) *covingtonense.* Cross-section of same specimen as plate XLV, figs. 2A, B.

Fig. 10. *Ormoceras ferecentricum.* Cross-section of same specimen as plate XLIX, figs. 2A, B.

Fig. 11. *Kochoceras cf. tyrrelli.* Cross-section of specimen numbered C, 2673 in the British Museum of Natural History, from Great Slave Lake, presumably from the Red River formation. Figured by Foerste in The cephalopods of the Red River formation of Southern Manitoba, in Jour. Sci. Lab. Denison Univ., vol. 24, 1929, pl. 28, fig. 2; pl. 29, figs. 1A, B.

Fig. 12. *Elrodoceras telleri.* Cross-section of same specimen as plate XLVII, fig. 2.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## PLATE LIX

Fig. 1. *Leurorthoceras lebanonense*. Cross-section of same specimen as plate XLII, figs. 1A, B.

Fig. 2. *Ormoceras lindsleyi*. Cross-section of same specimen as plate LIII, figs. 2A, B, C.

Fig. 3. *Ormoceras troosti*. Cross-section of same specimen as plate L, figs. 2A, B.

Fig. 4. *Rayonnoceras bassleri*. Cross-section of same specimen as plate LII, figs. 1A, B.

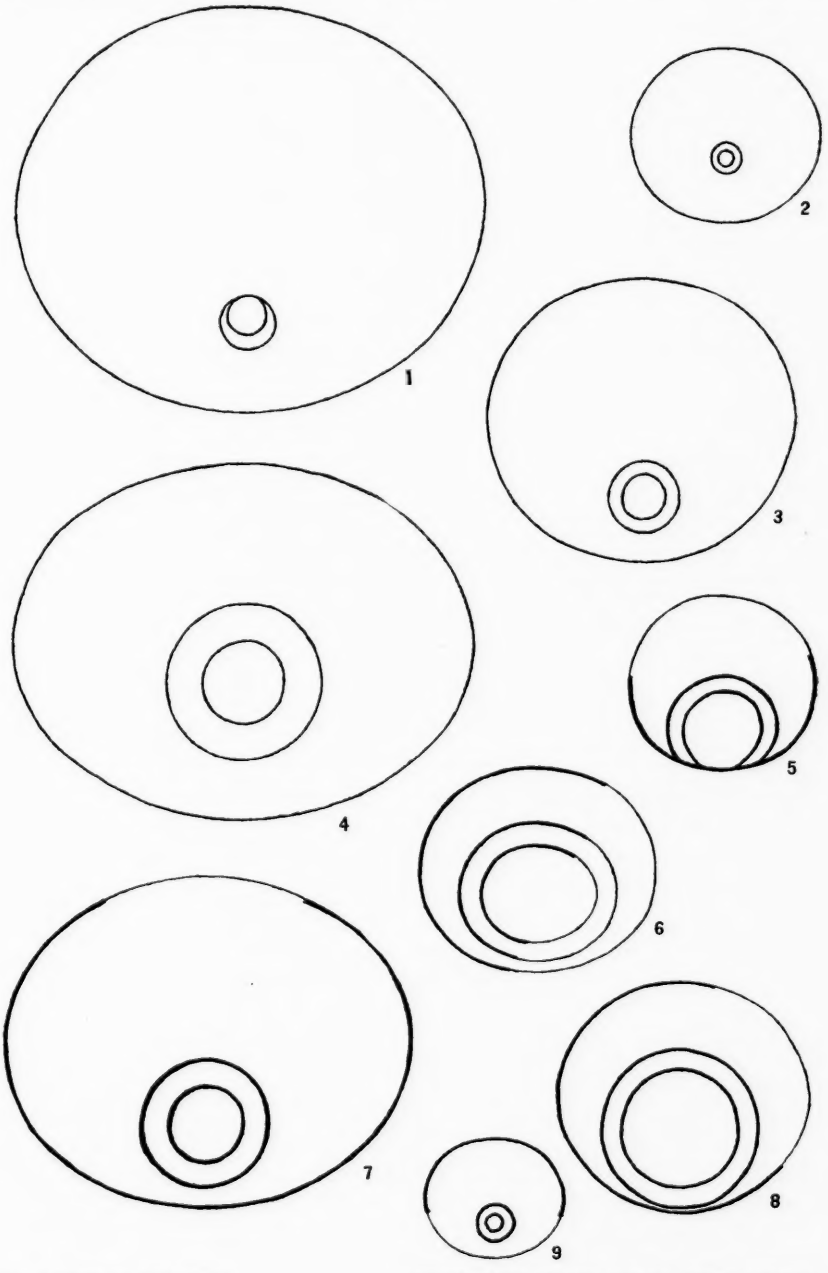
Fig. 5. *Troostoceras paulocurvatum*. Cross-section of same specimen as plate LIV, figs. 1A, B, C.

Fig. 6. *Actinoceras bigsbyi*. Cross-section of same specimen as plate XL, fig. 3. See also plate LVI, figs. 2, 5.

Fig. 7. *Actinoceras beloitense*. Cross-section of same specimen as plate XXX, figs. 1A, B.

Fig. 8. *Actinoceras tennesseense*. Cross-section of same specimen as plate XXXV, figs. 2A, B.

Fig. 9. *Ormoceras normanense*. Cross-section of same specimen as plate LIII, figs. 3A, B, C.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# THE PRESENCE OF NYBYOCERAS IN SOUTH MANCHURIA

RIUJI ENDO

*Manchurian Teachers' College, Mukden, Manchuria*

*Received November 5, 1930; published December 23, 1930*

In September, 1927, a geological excursion of the Manchurian Teachers' College went to the northern part of the Pen-hsi-hu coal basin, and there one of the students, Mr. D. Nishimoto, collected a rather good specimen of an actinoceroid cephalopod from the limestones of the Wuting formation, and, in addition, the following characteristic fossils found at the same horizon:

*Orthis calligramma orthoambonites* von Buch (de Verneuil)
*Raphistoma* cf. *aequilaterum* Koken?
*Helicotoma* sp.
*Cycloceras marginale* n. sp.
*Plectoceras ohtakai* n. sp.
*Actinoceras numatai* n. sp.
*Ormoceras manchuriense* n. sp.
*Bathyurus* (?) sp.

Though most of the species listed above are new or undetermined, the general character of this fauna is quite distinctive, and is similar to that of the Athens shale of the Upper Chazyan of North America, thereby indicating a corresponding age for the Wuting formation of Manchuria.

A polished section of the actinoceroid cephalopod mentioned in the first paragraph reveals that this specimen belongs to the genus *Nybyoceras.*[1]

The finding of *Nybyoceras* in the Upper Chayzan of Manchuria was unexpected, because Troedsson obtained his genotype—the only species hitherto known—in the Lyckholm beds ($F^1$), in

[1] Troedsson, Gustaf T., On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, p. 106, pl. 63, figs. 1–3, 1926.

Esthonia, which are equivalent to the Richmond. Dr. Teichert informed me that he had collected two additional species of *Nybyoceras*[2] from the same horizon as the genotype at the type locality in Esthonia.

The Wuting formation is much older than the Lyckholm. However, in the present issue of this Journal Aug. F. Foerste and Curt Teichert describe a species of *Nybyoceras* from the Lower Chazyan of Oklahoma under the name *Nybyoceras ulrichi*, the specimen having been collected by Dr. E. O. Ulrich. Thus the occurrence of *Nybyoceras* in Manchuria is of considerable interest, both on account of its stratigraphic position in the Upper Chazyan and on account of the evidence it presents of a wide geographic distribution of this genus. The description of the Manchurian species follows:

**Nybyoceras foerstei** Sp. nov.

*Plate LX, figs. 1 A, B, C*

Specimen 127 mm. long; its apical angle seems to be rather small. The cross-section of the conch is somewhat depressed, but the siphuncle is circular. A part of the dorsal side of the conch has weathered away. The dorsoventral diameter is about 57 mm., while its lateral one is about 63 mm. The number of camerae in a length equal to the lateral diameter of the conch is 7. The diameter of the siphuncle is 21 mm. at the top of the specimen. The ratio between the diameter of the siphuncle and the dorsoventral diameter of the conch is 0.37. The distance of the siphuncle from the ventral wall of the conch is 3 mm. at the top of the specimen. The siphuncle is strongly nummuloidal and its interior is filled with actinoceroid deposits of calcareous material, leaving a central endosiphuncular passage. Septal necks rather conspicuous. On the dorsal side of the conch the septa are in contact with the segments of the siphuncle beneath instead of those above; but ventrally they are conspicuously in contact with the segments above, and laterally the same form of

[2] Teichert, Curt, Die Cephalopodenfauna der Lyckholm-Stufe des Ostbaltikums. Pal. Zeitschrift, vol. 12, 1930. (In press.)

contact predominates. This is the type of structure on which Troedsson founded his genus *Nybyoceras*. On the dorsal side of the conch a deposit of calcareous material covers both the upper and the lower side of the septa, and on its ventral side the interior of the camerae is almost filled by a similar deposit. The sutures of the septa are very oblique. The surface of the shell apparently was smooth.

Occurrence.—Lower Ordovician, in the Wuting formation; in black-banded limestone beds, near San-tao-kang-tzu, 1.5 miles north of Pen-hsi-hu colliery, Liao-tung, Manchuria. The specific name is given in honor of Dr. Aug. F. Foerste, from whom I received valuable assistance in my study of Manchurian Ordovician fossils.

Remarks.—This species is readily distinguishable from *Nybyoceras bekkeri* Troedsson, from the Lyckholm beds at Nyby, Esthonia by the relatively smaller diameter of its siphuncle and the shorter length of its camerae.

## PLATE LX

Fig. 1. *Nybyoceras foerstei* Endo. A, dorsoventral section of conch through the siphuncle, with ventral outline on right; B, lateral view with ventral outline on right; C, basal view, showing location of siphuncle. Found near San-tao-kang-tzu, one and a half miles north of the Pen-hsi-hu colliery, Liao-yang, Manchuria, in the Wuting formation, of Lower Ordovician age.

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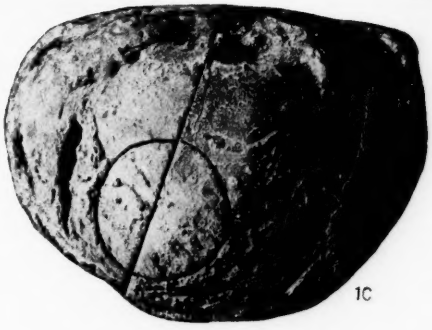
1B



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